INTRODUCTION

Uncovering the body of scientific knowledge, the development of the vast array of designed products, and the associated intellectual activities are the work of scientists and engineers. Students, in their pursuit of core scientific knowledge, engage in similar work. The intellectual activities (science and engineering practices) represent one dimension of the Next Generation Science Standards (NGSS). Some of these practices are innately natural for students as they observe and tinker with the world around them. Others may be alien at first, but with support and guidance from teachers, will become part of the way students think and work in science.

Engaging in the practices of science helps students understand how scientific knowledge develops; such direct involvement gives them an appreciation of the wide range of approaches that are used to investigate, model, and explain the world. Engaging in the practices of engineering likewise helps students understand the work of engineers, as well as the links between engineering and science. Participation in these practices also helps students form an understanding of the crosscutting concepts and disciplinary ideas of science and engineering; moreover, it makes students’ knowledge more meaningful and embeds it more deeply into their worldview.

The actual doing of science or engineering can also pique students’ curiosity, capture their interest, and motivate their continued study (A Framework for K–12 Science Education, 2012, page 42).

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Science and Engineering Practices

There are eight practices described in *A Framework for K–12 Science Education*. The practices are the same for K–2, but the capabilities form a learning progression described in grade bands—K–2, 3–5, 6–8, and 9–12. Below are the capabilities for the grades K–2 grade band. Those in bold are emphasized in grade K based on the NGSS performance expectations.

1. **Asking questions and defining problems**
   - Ask questions based on observations to find more information about the natural and/or designed world(s).
   - Ask and/or identify questions that can be answered by an investigation.
   - Define a simple problem that can be solved through the development of a new or improved object or tool.

2. **Developing and using models**
   - Distinguish between a model and the actual object, process, and/or events the model represents.
   - Compare models to identify common features and differences.
   - Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s).
   - Develop a simple model based on evidence to represent a proposed object or tool.

3. **Planning and carrying out investigations**
   - With guidance, plan and conduct an investigation in collaboration with peers (for K).
   - Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question.
   - Evaluate different ways of observing and/or measuring a phenomenon to determine which way can answer a question.
   - Make observations (firsthand or from media) and/or measurements to collect data that can be used to make comparisons.
   - Make observations (firsthand or from media) and/or measurements of a proposed object or tool or solution to determine if it solves a problem or meets a goal.
   - Make predictions based on prior experiences.
4. **Analyzing and interpreting data**
   - Record information (observations, thoughts, and ideas).
   - Use and share pictures, drawings, and/or writings of observations.
   - Use observations (firsthand or from media) to describe patterns and/or relationships in the natural and designed world(s) in order to answer scientific questions and solve problems.
   - Compare predictions (based on prior experiences) to what occurred (observable events).
   - Analyze data from tests of an object or tool to determine if it works as intended.

5. **Using mathematics and computational thinking**
   - Decide when to use qualitative vs. quantitative data.
   - Use counting and numbers to identify and describe patterns in the natural and designed world(s).
   - Describe, measure, and/or compare quantitative attributes of different objects and display the data using simple graphs.
   - Use quantitative data to compare two alternative solutions to a problem.

6. **Constructing explanations and designing solutions**
   - Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena.
   - Use tools and/or materials to design and/or build a device that solves a specific problem or a solution to a specific problem.
   - Generate and/or compare multiple solutions to a problem.

7. **Engaging in argument from evidence**
   - Identify arguments that are supported by evidence.
   - Distinguish between explanations that account for all gathered evidence and those that do not.
   - Analyze why some evidence is relevant to a scientific question and some is not.
   - Distinguish between opinions and evidence in one’s own explanations.

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**REFERENCES**

Science and Engineering Practices—Grade K

- Listen actively to arguments to indicate agreement or disagreement based on evidence, and/or to retell the main points of the argument.

- **Construct an argument with evidence to support a claim.**

- Make a claim about the effectiveness of an object, tool, or solution that is supported by relevant evidence.

8. **Obtaining, evaluating, and communicating information**

- Read grade-appropriate texts and/or use media to obtain scientific and/or technical information to determine patterns in and/or evidence about the natural and designed world(s).

- Describe how specific images (e.g., a diagram showing how a machine works) support a scientific or engineering idea.

- Obtain information using various texts, text features (e.g., headings, tables of contents, glossaries, electronic menus, icons), and other media that will be useful in answering a scientific question and/or supporting a scientific claim.

- **Communicate information or design ideas and/or solutions with others in oral and/or written forms using models, drawings, writing, or numbers that provide detail about scientific ideas, practices, and/or design ideas.**

While these are presenting in this order, the Framework issues a word of caution.

*In doing science or engineering, the practices are used iteratively and in combination; they should not be seen as a linear sequence of steps to be taken in the order presented* (A Framework for K–12 Science Education, 2012, page 49).

**Science and Engineering Practices in FOSS Investigations**

One goal of the FOSS Program is scientific literacy for all students. This means more than just knowledge of core ideas. Scientific literacy includes engaging in the activities and intellectual behaviors of scientists and engineers. Written into each investigation are specific steps that aim to build student competence with each practice. Over the course of the year, the expectation is for all students to have multiple experiences with the practices. Student capabilities with each practice should advance as the year progresses. Teachers will need to purposefully plan instructional opportunities in order to advance these capabilities.
Throughout the *Investigations Guide* you will see specific practices called out in the sidebar next to a step. The table “Science and Engineering Practices Opportunities in FOSS” at the end of this chapter is the complete list. In some cases, you will also see a Teaching Note (see sidebar) instructing you to look at a specific section of this chapter to engage students in that practice. These grade-level examples for practices that are described in this chapter are shown in the table below.

For example, a strategy called “put in your two cents” can be used for developing an argument to determine whether or not worms are good for soil. In other cases, the teacher will need to decide how best to advance student capabilities throughout the year. This can be through a series of questions and frames or through mini-lessons suggested in this chapter. Prior experiences, amount of time, and complexity of the investigation factor into these decisions. At times, a deep dive into constructing explanations is a reasonable endeavor, other times, introducing a data collection tool is appropriate. The driving idea is for teachers to make purposeful decisions about when and how to engage students so within each practice their skills grow over the year.

Go to FOSSweb for Teacher Resources and look for the Science and Engineering Practices—Grade K chapter for details on how to engage students with the practice of constructing explanations.

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Grade-level examples for practices described in this chapter.
Supporting Student Engagement with Practices

In order to support students with the practices, teachers will want to utilize a combination of instructional strategies. Listed below are general strategies that can be used for any practice. Strategies for specific science and engineering practices are shared in the following sections.

**Questions, frames, and prompts.** Questions can focus student attention on a specific practice. Ideally, these questions should probe for students to communicate their thinking about one practice at a time to maintain focus. The teacher can provide frames and prompts for students to communicate and organize their thinking. Specific questions, frames, and prompts are provided for each practice in the corresponding sections.

**Teacher think-aloud.** The teacher can model the path an expert takes with a specific practice by verbalizing or modeling the thinking process. This is especially important for younger students who are just starting to work with the practices. For example, “When I think about planning an investigation, I think about which step I should take first and write that down or draw a picture of what I am doing. Next, I need to _____.” Or use statements, such as “What Roy just said makes me think I should try to find one more piece of evidence. I should include more evidence to make my argument stronger.” Modeling shows students what the expectations are, and helps them understand the structure and scope of each practice.

**Critique teacher-generated examples.** The teacher can provide a partially developed example or use of the practice, such as a procedure that is out of order or a drawing of a tree that is missing leaves.
WORKING WITH PRACTICES

Asking Questions (Science) and Defining Problems (Engineering)

Asking questions is essential to developing scientific habits of mind. Even for individuals who do not become scientists or engineers, the ability to ask well-defined questions is an important component of science literacy, helping to make them critical consumers of scientific knowledge (A Framework for K–12 Science Education, 2012, page 54).

As students engage with phenomenon through active investigation, they should begin to ask questions. Kindergarten students ask lots of questions when they work with new materials. These initial questions may not be questions that will lead to uncovering essential truths about the natural world and often need to be refined. Student actions as they work with materials are usually cause-and-effect questions, such as “What happens when I give the ball a big push?” Students might need guidance to connect these actions with questions that can be investigated. For example, when students are testing how far a ball will roll, the teacher might say, “It looks like you are rolling the ball from different places on the ramp and seeing how far it goes. You are trying to find out where the ball rolls the farthest.” Other questions, such as “Why is the ball red?” are not ones students can answer through investigation. Students should engage with probing questions to come to understand the nature of meaningful questions; the systematic process of seeking and acquiring answers. Additionally, new questions should arise as a result of observing during investigations, continuing the process. Questions about phenomena, such as balls rolling down ramps, will increase in complexity as student knowledge of a subject increases.

When students begin to confront engineering challenges, they need to define the problem they need to solve. As they design, construct, test, and redesign, they often might have new problems they need to solve. Defining both the overarching problem as well as those problems that arise along the pathway toward a solution are important for students to recognize and communicate during their work.

Working with students asking questions and defining problems.

Asking questions and defining problems can occur at any time. In the Investigations Guide there are specific steps where teachers can probe for student questions. These should not be viewed as the only opportunities for students to ask questions.

A big step in a teacher’s practice is the ability to recognize student questions about their learning and help them clarify questions about their own understanding. It is not the teacher’s job to answer all of

Appendix F of NGSS identifies student capabilities as they ask questions and define problems. Those in bold appear in the performance expectations for grade K.

- Ask questions based on observations to find more information about the natural and/or designed world(s).
- Ask and/or identify questions that can be answered by an investigation.
- Define a simple problem that can be solved through the development of a new or improved object or tool.
those questions. When students ask questions, the teacher sorts those questions (in their head) into four categories and then takes appropriate action.

1. **Questions that are reasonable for students to investigate, even if they need some refining.** Suggestions for helping students reword or focus these questions are provided below.

2. **Questions that can be answered by information acquisition through readings, or other sources.** For suggestions to help students obtain information through other sources, see the section in this chapter on obtaining, evaluating, and communicating information.

3. **Questions that can be answered by thinking and analysis of available information during a sense-making discussion.** Suggestions for working with questions can be found in the Sense-Making Discussions for Three-Dimensional Learning.

4. **Questions that are fanciful or developmentally out of the cognitive range of students.** For the latter, teachers should aim to keep the curiosity of students intact but not feel compelled to pursue the question. A simple, “So you are wondering <student’s question>. I’m curious about that too,” works reasonably well.

**Example in Grade K**

Ask questions based on observations to find more information about the natural and/or designed world(s). In the Animals Two by Two Module, Investigation 1, Part 4, students have observed goldfish and are introduced to guppies. Students observe the guppies and begin to make comparisons between the two fish. Students are asked what questions they have about guppies. In this example, the teacher wants to support students in asking questions as this is her first module in the year. The teacher uses an instructional strategy to help students ask questions about their observations. The teacher asks students what is something they observed about guppies. For example, some of the guppies have colored dots on them and some do not. Taking this observation, the teacher can rephrase this as a question, such as, “What are the colored dots?” After recording this question on the board or in a class notebook, students can share other observations. After the teacher rephrases these as questions, the teachers make an observation, such as, “I saw the goldfish eat elodea, but I didn’t see the guppies eat anything. What is a good question we can ask?” Students can rephrase the teacher’s observation as a question. Later in the module, students are asked to develop questions again, she revisits
these questions about the guppies and asks students to think about questions or share observations for the new topic. If a student shares an observation, she asks students to rephrase the observation as a question. The teacher can provide guidance such as, “I wonder if we can ask a question that is similar to _____.” She wants students to improve asking their own questions.

**Additional strategies for asking questions and defining problems.**

**Ask and/or identify questions that can be answered by an investigation.** Generate a list of questions with students after a common experience with a phenomenon. These questions should be written on the board or on sentence strips. Questions should be ones that students could answer using materials and some that they cannot. For example, “What would happen if you used the sandpaper really fast?” and “Who made the sandpaper?” Have a discussion about what would have to be done to answer those questions. Guide students to sorting the questions into “ones we could answer” and “ones we can’t answer.” As time permits, allow students to investigate some of the questions.

As students progress through the year, take one of the questions in the “ones we can’t answer” group and model how to rephrase the question. For example, “Who made the sandpaper?” could be, “How do you make sandpaper?” Students can work on rephrasing other questions in the group. Towards the end of the year, record a number of questions and have students sort them. Ask them how they could change part of the question to make it one they can investigate.

**Define a simple problem that can be solved through the development of a new or improved object or tool.** As students engage with phenomena, they may have shared engineering experiences, and opportunities to identify problems, both in and beyond the classroom. When introducing the design problem, have students turn and restate the problem in their own words with a partner. These problems can be recorded on a piece of chart paper throughout design process. As the year progresses and students begin to develop their own engineering problems to solve, similar strategies to those shared above can be used.

**Sentence frames for students to use to ask questions and define problems.**

- What does _____?
- Where is _____?
- When I _____ why does _____?

*Science and Engineering Practices—Grade K*
• When does _____?
• Why is _____?
• Why does _____?
• I predict _____.
• I wonder _____.
• What would happen if _____?
• What causes _____?
• What is the effect of _____?
• How does _____ affect _____?
• What would change if _____?
• I predict _____ because _____.
• The problem we will solve is _____.

Questions for teachers to ask students about asking questions and defining problems.

• Which of these questions are you wondering about?
• Which of these parts do you want to change?
• Could _____ be the problem you might solve?
• What questions do you have about _____?
• What questions do you have about what you might change?
• What questions could you ask to find out _____?
• What is the problem we are trying to solve?
• How might we solve this problem?
• What do you need to know about _____?
Developing and Using Models

Scientists use models (from here on, for the sake of simplicity, we use the term “models” to refer to conceptual models rather than mental models) to represent their current understanding of a system (or parts of a system) under study, to aid in the development of questions and explanations, and to communicate ideas to others. Models can be evaluated and refined through an iterative cycle of comparing their predictions with the real world and then adjusting them, thereby potentially yielding insights into the phenomenon being modeled. (A Framework for K–12 Science Education, 2012, page 13.)

As students explore phenomena, systems, and the world around them, they formulate models about phenomena and how and why things work the way they do. These models, either emerging or fully developed, guide questions and explanations about the working of the natural world. Students represent their models and use them to communicate and test their ideas about cause-and-effect relationships.

Working with students developing and using models.

The Investigations Guide identifies steps in which students can develop and use models. Initially, students formulate primitive models to explain phenomena and how the world works with naive intuitive thinking. Their models will often be drawings with some thinking attached to them. The teacher can ask questions or provide experiences to guide further development of the model. Depending on the timing, questions might be asked when the teacher is listening to a small group. Questions such as, “How does that work?” and “What would the happen if you added another paperclip to your raft?” will prompt students to improve their model. During a sense-making discussion, the teacher can have students share their models with others, providing a way to get feedback and think critically about how to make adjustments. As the year progresses, the teacher scaffolds the development of students’ own models based on data.

Strategies for developing and using models.

Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s). In the Animals Two by Two Module, Investigation 3, Part 2, students create a worm jar to observe the worm interacting with the environment, a natural relationship. Students record their observations in their notebooks over several weeks. The worm jar serves as a model for how worms live in the natural environment. The teacher can support students in using this model during the sense-making discussion by asking students to observe how the worms change their environment in the jar. Using these observations, students can consider how worms would interact with their natural environment.
Develop a simple model based on evidence to represent a proposed object or tool. When developing a model of a tool or object, the teacher needs to carefully guide students through the process initially. For example, students are challenged to build a structure that will keep water cool in the sunshine in the Materials and Matter Module. This can begin by guiding a discussion about what they observed when they placed a cup of water in the shade and one in the sunlight. Students identify that the water in the shade was cooler. Show students one of the available materials and ask guiding questions, such as, “Do you think this material might be used to provide shade?” Continue the discussion by doing think-alouds as you hold up one object at a time. “I wonder what this might be used for.” “Could I use this to hold something up?” Have students turn and talk about how they could use a particular material. Providing this guidance focuses students’ designs. Allow students to visit with others and get ideas to try in their model. As the year progresses, continue to review what observations students have made that aid the design process. Present students with a few of the materials they can use at a time rather than one at a time.

Distinguish between a model and the actual object, process, and/or events the model represents and compare models to identify common features and differences. Ideally, young students should work directly with actual objects or processes. For example, in the Materials and Motion Module, students create a model piece of plywood by gluing three thin pieces of wood together. They make comparisons between the actual process, shared on a poster, and the model process. When students are comparing a model to an actual object or process, provide structured opportunities for students to focus on one aspect or step. For example, students can compare the first step of their model to the actual creation of plywood. Ask questions such as, “What is the same about the first step you did and the first step in the lumber mill?” Think-alouds also provide insight for students to make comparisons between two models. To further support students when comparing models, ask students to generate words, such as smaller or larger that can be used to identify differences. In certain cases, such as the worm jar, the model does not represent all aspects of the natural environment. Students might be able to identify one of the main differences between the two is the natural environment contains animals that eat worms.
Sentence frames for students to use to develop and use models.

• The model shows _____.
• The model doesn’t show _____.
• The parts of my model are _____.
• This model is different because _____.
• My model shows how _____ changes _____.
• I changed my model because _____.

Questions for teachers to ask students about developing and using models.

• How can you make a drawing in your notebook to explain _____?
• What could you add to your model to show _____?
• Does this part mean _____?
• What ideas could you add to your model?
• What changes could you make?

Here are other examples of developing and using models in FOSS grade K modules.

• In the Trees and Weather Module, students develop and use models to describe the parts of trees.
• In the Materials and Motion, Module, students develop and use models to describe fabric.
• In the Animals Two by Two Module, students develop models of goldfish aquariums.
Planning and Carrying out Investigations

Scientists and engineers investigate and observe the world with essentially two goals: (1) to systematically describe the world and (2) to develop and test theories and explanations of how the world works. In the first, careful observation and description often lead to identification of features that need to be explained or questions that need to be explored (A Framework for K–12 Science Education, page 59).

Students plan and carry out investigations in pursuit of data to be analyzed. Investigations can be conducted under teacher guidance in order to gain experience with controlling variables, using tools such as balances or thermometers, and making sufficient observations. Students can contribute to a common class or group investigation in which materials and procedures are identified. Predictions can be made based on observations and analysis of cause-and-effect relationships.

**Working with students planning and carrying out investigations.**

Much like other practices, students in kindergarten will need guidance in carrying out investigations. These experiences will serve as a starting point for students. When investigating phenomena, a teacher needs to consider the allocation of time, the level at which students can plan and conduct, and what skills students can develop during the lesson. In the Investigations Guide, procedures might be provided for everyone to follow for the first time. Later in the module, students might develop procedures collaboratively with the teacher’s guidance. Teachers will need to adjust their expectations to the skill and experiences of their students. Similarly, instructions on how to use tools accurately will be introduced during an early investigation and the teacher will need to monitor the use of the tool throughout the year.

The data collected while carrying out investigations is often recorded on a provided notebook sheet or students can develop their own recording method with teacher support. Again, the teacher needs to determine the time available and the prior experience of students.

**Example in Grade K**

With guidance, plan and conduct an investigation in collaboration with peers (for K) and Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question. In the Motion and Matter Module, Investigation 3, Part 3, Steps 3–6, students are asked to observe water on fabric and make a decision about which fabric would be a good material for a raincoat. The teacher provides guidance for placing a few drops of water on the first piece of fabric and asking questions to guide observations. The students repeat the procedure and...
observations for two additional pieces of fabric. Before testing other fabrics, students are asked how they can test those and how they can record their results. In this example, the teacher structures and guides the procedure and observations as students test water on three different fabrics.

As students demonstrate the ability to follow procedures and make observations, the teacher shifts the responsibility to the students. Many investigations in FOSS have indicated steps for students to use to produce data. Some of these have prepared notebook sheets with a data collection tool. These can serve as resources for students to reference when developing their own methods. Students can record their observations in the class notebook to serve as models for other students. As the year progresses, guidance is still provided for new procedures and ways to make observations, however, scaffolds are gradually removed as skills increase.

**Strategies for planning and carrying out investigations.**

Evaluate different ways of observing and/or measuring a phenomenon to determine which way can answer a question. Time and effort for students to record data is at a premium in kindergarten. In order to best evaluate different ways to observe a phenomenon, students need experience in different methods. Guide students in making quality observations by asking questions such as, “Would it be better to look at the goldfish from the side or from the top to see all of the parts?”

Make observations (firsthand or from media) and/or measurements of a proposed object or tool or solution to determine if it solves a problem or meets a goal. When students are presented with an engineering challenge, they need to observe to see if the designed object, tool, or solution meets the challenge. Ask students questions related directly to the challenge throughout the design process, such as “What does the ball need to do in order to make it into the pond?” and “Was the ball redirected into the pond?” As the year progresses, questions become, “What are you trying to get the ball to do?” and “What did you observe that makes you think you solved your problem?” This allows students to connect their observation to the criteria of the challenge.

Make predictions based on prior experiences. Making predictions in kindergarten, as well as other grades, needs to be based on prior experience. In many cases, the Investigation Guide provides prompts for students to make predictions at the appropriate time. A good way to help students make predictions is to generate a list of
possible outcomes first by asking, “What could happen when we <change you are making>?” This allows students to consider all the possible outcomes before firming up which one they believe will happen. A general rule, if students cannot think of possible outcomes or make reasonable predictions, they need more experience or have not yet discovered a pattern in the data. In these cases, provide the experience rather than waiting for predictions and revisit it later.

When you do hear students excitedly make predictions in the spur of the moment, seize the opportunity and ask them, “Why do you think that will happen? What have you observed before that makes you think that?” These questions connect predictions to observed patterns.

Sentence frames for students to use to plan and carry out investigations.

• First, we will _____ .
• Next, we will _____ .
• Then, we will _____ .
• If we change _____ , then _____ .
• I predict _____ because _____ .
• I observe _____ .
• I want to find out ____.
• We could ______ to see if _____.

Questions for teachers to ask students about planning and carrying out investigations.

• Are you trying to find out _____ ?
• Have you thought about _____ ?
• What will you do first? Second?
• Will you need _____ ?
• Does _____ meet the criteria?
• What are you trying to find out?
• How could you find out _____ ?
• Is there another way?
• What materials will you need?
• How will you test _____ ?
• Is there anything else you want to find out?
Analyzing and Interpreting Data

At the elementary level, students need support to recognize the need to record observations—whether in drawings, words, or numbers—and to share them with others. As they engage in scientific inquiry more deeply, they should begin to collect categorical or numerical data for presentation in forms that facilitate interpretation, such as tables and graphs (A Framework for K–12 Science Education, 2012, page 63).

Once data have been collected, they must be organized for interpretation and analysis. Students initially need guidance on how to organize and display numerical data in tables or graphs. Narrative observations also need to be organized in logical ways so students can analyze them. Through teacher guidance, students should strive to discover patterns in their data. In engineering, this analysis can help determine if design changes resulted in the desired effect.

Working with students analyzing and interpreting data

As students carry out investigations, they collect data in various forms. Students need to learn how those data can be organized for analysis. In the Investigations Guide, suggestions are made for data collection tools. Some might require a mini-lesson; others might be accomplished through questioning and discussion. The Science Notebook in Grades K–2 chapter discusses strategies for guiding students’ use of organizing tools, such as tables, graphs, and drawings.

When data are organized, teachers need to help students analyze and interpret data. This can often be done effectively during sense-making discussions. In a sense-making discussion, the teacher poses questions to guide students to uncover patterns and relationships. See the Sense-Making Discussions for Three-Dimensional Learning chapter for more information on how to conduct this type of discussion with students.

Example from Grade K

Use observations (firsthand or from media) to describe patterns and/or relationships in the natural and designed world(s) in order to answer scientific questions and solve problems and Analyze data from tests of an object or tool to determine if it works as intended. In the Materials and Motion Module, Investigation 1, Part 3, Steps 17 and 18, students test how many paper clips different pieces of wood would hold before sinking in water. Students are asked to remove the paper clips (passengers) and place them next to the corresponding wood (raft) so they form a physical bar graph. Having students construct physical graphs such as this helps them visually see the amounts. After they make these graphs, questions are asked during the sense-making discussion to help students

Appendix F of NGSS identifies student capabilities as they analyze and interpret data. Those in bold appear in the performance expectations for grade K.

- Record information (observations, thoughts, and ideas).
- Use and share pictures, drawings, and/or writings of observations.
- Use observations (firsthand or from media) to describe patterns and/or relationships in the natural and designed world(s) in order to answer scientific questions and solve problems.
- Compare predictions (based on prior experiences) to what occurred (observable events).
- Analyze data from tests of an object or tool to determine if it works as intended.

Science and Engineering Practices—Grade K
analyze the data from the test. Questions include, “Which piece of wood took more paper clips to sink, the cedar or the particleboard?” and “How could you tell without counting paper clips?” With other types of data, such as drawings, similar questions can be asked. The Investigations Guide and the Sense-Making Discussions for Three-Dimensional Learning chapter contain information about questions to ask and how to scaffold these discussions over the course of the year. Some investigations allow students to focus on the cause-and-effect relationships and others focus on patterns. Strategies for working with these are shared in the Crosscutting Concepts for Grade K chapter.

Other strategies for analyzing and interpreting data.

Record information (observations, thoughts, and ideas) and use and share pictures, drawings, and/or writings of observations. The Investigations Guide provides recommendations for when students should record information for further analysis during the sense-making discussion. The Science Notebooks for Grades K-2 chapter shares specific strategies for ways students can record, use and share their observations over the course of the year.

Compare predictions (based on prior experiences) to what occurred (observable events). As indicated in the planning and conducting investigation section, students make predictions about what might happen when a change is made. Be sensitive when asking students to compare their predictions to what occurred. Students might interpret their predictions as wrong or even go as far as trying to erase their original predictions. Focus the attention on why they made the prediction rather than if it is right or wrong. A safe way to do that is to say something like, “I really thought the particleboard would hold more paper clips because I thought it was lighter. That made sense to me at that time. Now that I have seen this, I wonder what makes the piece of cedar hold more before sinking.” In this example, the teacher took ownership of a prediction that was reasonable (and likely similar to many students) and used it as an opportunity to ask a question. A scientist or engineer might say, “Hmmm, that’s strange, I wonder why that happened.”

Sentence frames for students to use to analyze and interpret data.

- I observe _____.
- It looks _____.
- It feels _____.
• It smells _____.
• It sounds like _____.
• I think _____.
• _____ reminds me of _____.
• My picture shows _____.

Questions for teachers to ask students about analyzing and interpreting data.

• Do you observe _____?
• Is this a pattern?
• Are these the same or different?
• Do you think it means_____?
• How could you start your drawing _____?
• Make a diagram to show _____?
• Does this mean your design works?
• What do you observe?
• What surprised you?
• Does this change what you think about _____?
• What patterns do you observe?
Using Mathematics and Computational Thinking

Mathematics and computational tools are central to science and engineering. Mathematics enables the numerical representation of variables, the symbolic representation of relationships between physical entities, and the prediction of outcomes. Mathematics provides powerful models for describing and predicting … (*A Framework for K–12 Science Education*, 2012, page 64).

Strongly connected to planning and carrying out investigation and interpreting and analyzing data, mathematics plays heavily into the work of science and engineering. Measurements and other quantitative data can be collected and organized in various arrays for analysis. These data can be used to support student models, explanations, and design solutions.

Working with students using mathematics and computational thinking.

Students need to understand the difference between qualitative and quantitative data and know when to use them. This requires guidance and discussion. Asking questions, such as, “Is this something we should describe using numbers or words?” are useful for students to consider. Quantitative data (things counted or measured) can be displayed in various ways for analysis. In kindergarten, introducing numbers, words, and simple graphs will serve as foundational skills for later grades when the capabilities (see the list in the sidebar) are further developed.

Strategies for using mathematics and computational thinking.

Most collection methods in kindergarten for both quantitative and qualitative are provided for students. When introducing these, have a quick discussion about why students are using number or words. Use a think aloud, such as, “I am going to count the number of fins on the goldfish and compare that to the number of fins on the guppy.” Also in the Investigations Guide, mini-lessons on how to make graphs are included when relevant.

Sentence frames for students to use for mathematics and computational thinking.

- We counted _____.
- There are more/less _____.
- The _____ is bigger/smaller _____.
- We found out that _____.
- The graph/table shows _____.
Questions for teachers to ask students about using mathematics and computational thinking.

- How many?
- How much?
- How long?
- How could you find out how many?
- How could you find out how long?

Here are examples of using mathematics and computational thinking in FOSS grade K modules.

- In the **Trees and Weather Module**, students use mathematics and computational thinking to discuss weather graphs.
- In the **Materials and Motion Module**, students use mathematics and computational thinking to graph the types of fabric used in pants.
Constructing Explanations and Designing Solutions

Engaging students with standard scientific explanations of the world—helping them to gain an understanding of the major ideas that science has developed—is a central aspect of science education. Asking students to demonstrate their own understanding of the implications of a scientific idea by developing their own explanations of phenomena, whether based on observations they have made or models they have developed, engages them in an essential part of the process by which conceptual change can occur. Explanations in science are a natural for such pedagogical uses, given their inherent appeals to simplicity, analogy, and empirical data (which may even be in the form of a thought experiment). And explanations are especially valuable for the classroom because of, rather than in spite of, the fact that there often are competing explanations offered for the same phenomenon—for example, the recent gradual rise in the mean surface temperature on Earth (A Framework for K–12 Science Education, 2012, page 68).

When students have analyzed data, they extract meaning and transfer that meaning to explain other observable phenomena and answer questions. These explanations, (in engineering—solutions), are based on data and/or models. Many questions are related to phenomena are such as, “What happens when water gets on paper?” When explaining the phenomenon of a cause-and-effect relationship, students should use observations. Claims, evidence, and reasoning is developed in upper and elementary and middle school where there are opportunities for students to reason sufficiently during a sense-making discussion.

Students utilize their scientific understanding to develop solutions to problems. Once solutions are developed, students carefully analyze data to determine whether the proposed solutions do or do not meet the established criteria and honor the constraints.

Working with students constructing explanations and designing solutions.

As students analyze and interpret data during sense-making discussions, they construct thoughts about phenomena, respond to questions, and design and evaluate solutions to problems. Teachers should guide students to communicate explanations with others, use sentences frames, and allow time for revision. During discussions, teachers should listen for explanations and use clarifying questions based on student responses. At the beginning, teachers might have students develop a claim as a class and model how to develop data into evidence to support their claim. As the year progresses, students develop their claims and select data to use as evidence independently. When appropriate, the teacher can push...
for model-based reasoning, or the “why <student claim> is happening.” When expressing their reasoning, teachers should encourage students to use relevant academic vocabulary and take ample time for this to be developed in discourse with peers.

In the Investigations Guide, specific focus questions guide each part. These questions call for students to construct an answer to the questions at the end of the part. While the focus questions pertain to one part, a guiding question is broader. Students construct explanations for the guiding questions for the investigation as well. These broader explanations connect to the Disciplinary Core Ideas and the natural or designed world.

Example in Grade K

Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena. In the Trees and Weather Module, Investigation 2, Part 3, students make comparisons of pictures of leaves and actual leaves they find outside. They find leaves that are longer, shorter, wider, or narrower than the reference leaves and make other comparisons as well. In making these observations, students determine various ways leaves are different. In the beginning of the year, students need a high level of scaffolding. Students can discuss how they would answer the focus question, “How are leaves different?” as a class. Comparison words such as wider and longer can be written on word cards. The class can answer the focus question together in the class notebook. As students progress through the year in both their writing ability and their skill in constructing explanations, the class notebook can be used to model a portion of constructing an explanation. The teacher might model how to tape in a leaf and use the sentence frame, “This leaf is ____ .” Students can answer the question orally in the discussion and when they use their own science notebook, they can access the comparing words on the word wall.

Other strategies for constructing explanations and designing solutions.

Use tools and/or materials to design and/or build a device that solves a specific problem or a solution to a specific problem and generate and/or compare multiple solutions to a problem. As students understand scientific ideas, they have the opportunities to transfer and apply those ideas to the designed world. As students begin to work on a particular problem, some might see the relationship between a design and the science experiences. Other students will need guidance through questioning such as those in the Investigations Guide to
Here are other examples of constructing explanations and designing solutions in FOSS grade K modules.

- In the Trees and Weather Module, students design a solution to catch wind after working with other wind catchers.

- In the Materials and Motion Module, students construct explanations about what effects the distance a balloon rocket travels.

- In the Animals Two by Two Module, students construct explanations based on their observations of the birds that visit the schoolyard.

make those connections. Allow some time for students to struggle with the problem. If the struggle becomes unproductive, call students to the discussion area and have a short review of the relevant science notebook entries they have made leading up to the day’s work. During the sense-making discussion, students can bring their design solutions and meet with another group. During this meeting, groups can share their solution, how it fits with the criteria and constraints. Depending upon classroom culture, comparisons can be made among groups, however, be sure to keep the focus on discussing the designs, not creating a competition.

Sentence frames for students to use to construct explanations and design solutions.

- I observed _____.
- I think _____ because _____.
- We could solve the problem by _____.
- The best way to solve the problem is _____.

Questions for teachers to ask students about constructing explanations and designing solutions.

- Are you saying _____?
- Does _____ mean that _____?
- Is _____ an example of _____?
- Do you think _____ is a result of _____?
- Which _____ caused _____?
- Does _____ relate to this new situation?
- Is _____ the same or different from _____?
Engaging in Argument from Evidence

Argument in science goes beyond reaching agreements in explanations and design solutions. Whether investigating a phenomenon, testing a design, or constructing a model to provide a mechanism for an explanation, students are expected to use argumentation to listen to, compare, and evaluate competing ideas and methods based on their merits (NGSS Appendices, 2013, page 62).

Argumentation involves the interplay of different explanations (claims and evidence). Good arguments to support claims are based on evidence derived from data, as well as sound reasoning. Ideally, these data come from students’ firsthand experiences, with additional information from peer and teacher input and relevant media. Sometimes students question the relevance or validity of evidence as part of the argumentation process, requiring clarification or refinement of data collection or analysis. Other times, students elucidate and successfully defend the reasoning used in an explanation.

Working with students engaging in argument from evidence.

In the process of constructing explanations and sharing designs, students may disagree with other students in the group. Conversations ensue. Students refine explanations when they debate the merits of alternate ideas in informal arguments or when you structure a more formal argument within the class. Allowing students to revisit, revise, and elaborate previous explanations is a desirable progression after scientific argumentation.

Teachers should carefully consider when and how to encourage argumentation to support the learning of science content, especially in kindergarten. Opportunities to engage students in argumentation, along with suggested strategies below, are indicated in the Investigations Guide at specific points in the investigations. Unplanned opportunities or “teachable moments” occasionally present themselves during lessons. Teachers should be ready to encourage students to engage in argumentation to elaborate ideas that emerge spontaneously during discussion.

Example in Grade K

Construct an argument with evidence to support a claim. In the Animals Two by Two Module, Investigation 3, Part 3, students observe worms interacting with their environment. They are asked, “Are worms good for soil?” In the beginning of the year, students should present verbal statements during a sense-making discussion. In their arguments by putting forth a claim and supporting evidence. Students might initially respond with one word. Prompt students by asking, “What did you observe that makes you believe that?” This asks...
for evidence. These arguments can be recorded in the class notebook and others can agree or disagree.

As the year progresses, their arguments will need development. One strategy is to model how to write a position and then identify and color-code portions of the arguments. Gather students on the rug, and write an argument statement on the board. Ask students which part of the statement is the claim. When all agree, underline the claim with one color, then underline the evidence statements with another color. As students develop their writing skills, they can begin to use this strategy with their own writing. The focus, question in the form “I think ___ because ___.”

Another strategy is to write a few claim statements and a few evidence statements on sentence strips. Put the strips on a pocket chart to match up as a class, or give each small group a set to work on together. Students should first determine which statement strips are claims and which constitute evidence. Next, they should match the evidence statements with the claims they support.

**Additional strategies for engaging in argument from evidence.**

**Identify arguments that are supported by evidence.** Present two arguments on the board, one containing evidence from students’ collected data the other with no evidence. Ask students to identify the claim in both arguments. Have them discuss which has evidence supporting the claim.

- Fish are animals.
- Fish use swimmerets for movement in the water.
- Male fish are bigger than females.

**Distinguish between opinions and evidence in one’s own explanation.** Make sure students understand the difference between opinion and scientific evidence. Opinions are based on what a person believes to be true or feels should be true. Evidence is based on observation and scientific data.

Give students a few prompts to generate explanations that might include an opinion, such as “What is the weather today?” Generate a list of responses on the board, such as “I like when it is windy,” and “The Sun is shining.” Have students discuss in small groups, which statements are opinions and which are observations. Underline opinions in red, evidence in blue. As an extension, have students take turns making a statement that the rest of the group determines to be an opinion or evidence.
Sentence frames for students to use to engage in argument from evidence.

- I claim _____.
- My evidence is _____.
- I agree/disagree with _____ because _____.
- What about _____?
- I used to think _____ but now I think _____.
- My model shows _____.
- My data show _____.

Questions for teachers to ask students about engaging in argument from evidence.

- Do you agree or disagree?
- Which explanation makes more sense to you?
- Which piece of evidence supports this claim?
- Is this an opinion or evidence?
- Do you agree or disagree?

Here are examples of engaging in argument from evidence in FOSS grade 3 modules.

- In the Trees and Weather Module, students engage in argument from evidence if trees change their surroundings.
- In the Materials and Motion Module, students engage in argument from evidence if wood is a good material to make a chair.
- In the Animals Two by Two Module, students engage in argument from evidence (observations) about the preferences of snails for food, surfaces to move on, and light.
Obtaining, Evaluating, and Communicating Information

Being literate in science and engineering requires the ability to read and understand their literatures. Science and engineering are ways of knowing that are represented and communicated by words, diagrams, charts, graphs, images, symbols, and mathematics. Reading, interpreting, and producing text are fundamental practices of science in particular, and they constitute at least half of engineers’ and scientists’ total working time (A Framework for K–12 Science Education, 2012, page 74).

Students’ first-hand experiences combined with the science and engineering practices are extended by engaging with texts and other sources of information. Skill is required to extract and connect information found in the readings, videos, and other media. Like other sources of information, these too need to be organized, analyzed, and resolved into explanations and arguments. As students communicate their scientific thinking and technical information, they need skills to do so effectively whether orally, written, or visually.

Working with students obtaining, evaluating, and communicating information.

Obtaining, evaluating, and communicating information in science requires part science practice and part language arts skills. The teacher needs to consider student abilities with reading, writing, speaking, listening, and vocabulary when engaging students with this practice. Scaffolds and modifications may be necessary for students to extract useful information from text and to other media and analyze it with data collected from first-hand experiences. The Investigations Guide provides suggestions for specific instructional strategies for the FOSS readings and media. The Science-Centered Language Development chapter also provides a wealth of strategies for communicating information through speaking and writing. The teacher needs to select the appropriate strategies for their students, monitor progress, and adjust accordingly over the year.

Example in Grade K

Read grade-appropriate texts and/or use media to obtain scientific and/or technical information to determine patterns in and/or evidence about the natural and designed world(s).

In the Trees and Weather Module, Investigation 1, Part 6, students have observed trees and plant and begin to care for a class tree. In this example, the teacher wants to develop student capability of comprehending grade-appropriate complex text. After students have shared their initial finding, they are asked to read an article in the FOSS
Science Resources book. The teacher provides specific questions about trees for students to consider as they read. As students read or listen to the text, they determine answers to their questions. During the sense-making discussion in Step 11, students discuss their responses. The teacher probes for students to cite specific evidence from the article or their observations.

**Strategies for obtaining, evaluating, and communicating information.**

Describe how specific images (e.g., a diagram showing how a machine works) support a scientific or engineering idea and obtain information using various texts, text features (e.g., headings, tables of contents, glossaries, electronic menus, icons), and other media that will be useful in answering a scientific question and/or supporting a scientific claim. As indicated previously, strategies for obtaining information from text are shared in many places. When working with diagrams and various text features, conduct a mini-lesson to explain what information the author is communicating or have students work with a partner to analyze the information. With the information from both text and visuals, students can ask questions, refine models, incorporate new information into their explanations, or engage in argument.

Communicate information or design ideas and/or solutions with others in oral and/or written forms using models, drawings, writing, or numbers that provide detail about scientific ideas, practices, and/or design ideas. See the Science-Centered Language Development chapter for strategies on how to build students’ ability to communicate information or design ideas.

**TEACHING NOTE**

See the Trees and Weather Module, Investigation 1, Part 6, Step 16 for the context related to this example. This is a location that we identified in the Investigations Guide as a good opportunity to develop the practice of obtaining, evaluating, and communicating information.

Here are other examples of obtaining, evaluating, and communicating information in FOSS grade 3 modules.

- In the Trees and Weather Module, students obtain, evaluate, and communicate information about the properties and structures of trees.
- In the Materials and Motion Module, students obtain, evaluate, and communicate information about forces involved in rolling objects.
- In the Animals Two by Two Module, students obtain, evaluate, and communicate information from books and media and integrate that with their first-hand experiences to construct explanations about living organisms.
## SCIENCE AND ENGINEERING PRACTICES OPPORTUNITIES IN FOSS

This is a complete listing of every instance where a science and engineering practice is called out in the sidebar of the FOSS Investigations Guide. The ones in bold are the grade-level examples described in this chapter.

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<thead>
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<th>Practices</th>
<th>Trees and Weather Module</th>
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| Ask questions based on observations to find more information about the natural and/or designed world(s). | Inv 1, Part 1, Step 7: Conduct more observations  
Inv 1, Part 5, Step 7: Focus question: What can we find out about our adopted trees?  
Inv 1, Part 6, Step 11: Have a sense-making discussion  
Inv 2, Part 1, Step 3: Go outdoors |
| Define a simple problem that can be solved through the development of a new or improved tool.              |                                                                                           |
| Use a model to represent relationships in the natural world.               | Inv 1, Part 2, Step 2: Use the tree-part cards at a center  
Inv 1, Part 3, Step 5: Focus question: What shapes are trees? |
| Compare models to identify common features and differences.               | Inv 1, Part 2, Step 2: Use the tree-part cards at a center  
Inv 2, Part 4, Step 2: Review edge |
<p>| Develop a simple model based on evidence to represent a proposed object or tool. |                                                                                           |</p>
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<td>Inv 1, Part 2, Step 2: Review uses of wood</td>
<td>Inv 1, Part 1, Step 2: Guide observations and discussions</td>
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<td>Inv 1, Part 3, Step 14: Focus question: How many passengers will a wood raft hold?</td>
<td>Inv 1, Part 2, Step 4: Renew the water</td>
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<td>Inv 1, Part 5, Step 8: Have a sense-making discussion</td>
<td><strong>Inv 1, Part 4, Step 4: Have a sense-making discussion</strong></td>
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<td>Inv 1, Part 7, Step 7: Review vocabulary</td>
<td>Inv 1, Part 4, Step 10: Share information about photos</td>
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<td>Inv 2, Part 2, Step 5: Investigate other paper samples</td>
<td>Inv 1, Part 4, Steps 11-12: Read and discuss “Fish Live in Many Places”</td>
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<td>Inv 2, Part 4, Step 1: Introduce paper recycling</td>
<td>Inv 1, Part 5, Steps 9-10: Go outdoors/Discuss bird sightings</td>
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<td>Inv 2, Part 5, Step 11: Discuss the dried bowls</td>
<td>Inv 1, Part 5, Step 16: Discuss bird movement</td>
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<td>Inv 3, Part 2, Steps 10-11: Read and discuss “What Is Fabric Made From?”</td>
<td>Inv 1, Part 5, Step 20: Answer the focus question</td>
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<td>Inv 3, Part 6, Step 13: Introduce the design challenge</td>
<td>Inv 2, Part 1, Step 4: Compare two types of water snails</td>
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<td>Inv 4, Part 2, Step 11: Introduce a design challenge</td>
<td>Inv 2, Part 3, Step 11: Observe snail structures</td>
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<tr>
<td>Inv 2, Part 2, Step 5: Investigate other paper samples</td>
<td>Inv 2, Part 3, Steps 18-19: Read and discuss “Water and Land Snails”</td>
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<tr>
<td>Inv 2, Part 5, Step 11: Discuss the dried bowls</td>
<td>Inv 3, Part 2, Step 5: Block the worm’s path</td>
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<tr>
<td>Inv 2, Part 6, Step 13: Introduce the design challenge</td>
<td>Inv 3, Part 2, Step 18: Have a sense-making discussion</td>
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<tr>
<td>Inv 4, Part 2, Step 11: Introduce a design challenge</td>
<td>Inv 3, Part 3, Step 5: Continue the investigation</td>
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<tr>
<td>Inv 1, Part 4, Step 4: Renew the water</td>
<td>Inv 4, Part 2, Steps 10-12: Read and discuss “Isopods”</td>
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</table>

**Science and Engineering Practices—Grade K**
### Science and Engineering Practices—Grade K

#### Practices

| Make observations (firsthand or from media) and/or measurements to collect data that can be used to make comparisons. | Inv 1, Part 2, Step 2: Use the tree-part cards at a center  
Inv 2, Part 1, Step 9: Have a sense-making discussion  
Inv 3, Part 1, Step 2: Go outdoors  
Inv 3, Part 3, Step 2: Guide wind-sock construction  
Inv 4, Part 1, Step 1: Introduce the investigation  
Inv 4, Part 2, Step 1: Review seeds  
Inv 4, Part 3, Step 2: Go outdoors  
Inv 4, Part 4, Step 1: Discuss winter trees  
Inv 4, Part 5, Step 6: Examine twig cross sections  
Inv 4, Part 6, Step 2: Sort twigs in vases  
Inv 4, Part 8, Step 2: Distribute bark photos  
Inv 4, Part 9, Step 5: Review vocabulary |
|---|---|
| Make predictions based on prior experiences. | Inv 3, Part 3, Step 2: Guide wind-sock construction  
Inv 4, Part 7, Step 2: Sort twigs in vases  
Inv 4, Part 8, Step 2: Distribute bark photos |
| With guidance, plan and conduct an investigation in collaboration with peers. | --- |
### Materials and Motion Module

- Inv 1, Part 1, Step 4: Explore wood samples
- Inv 1, Part 1, Step 12: Search outdoors for wood
- Inv 1, Part 2, Step 8: Look for patterns with other wood samples
- Inv 1, Part 3, Step 4: Describe sinking wood
- Inv 1, Part 4, Step 3: Focus question: How can you change the shape of wood?
- Inv 1, Part 5, Step 5: Combine the two materials
- Inv 2, Part 1, Step 2: Form groups and explore the paper samples
- Inv 2, Part 2, Step 5: Investigate other paper samples
- Inv 2, Part 3, Step 3: Ask questions to guide observations
- Inv 3, Part 1, Step 11: Begin the fabric hunt **Inv 3, Part 3, Steps 3–6: Drop water on terry cloth**
- Inv 3, Part 6, Step 21: Test structures
- Inv 4, Part 1, Steps 5-7: Introduce/practice rolling
- Inv 4, Part 2, Step 3: Introduce ramp
- Inv 4, Part 2, Step 8: Distribute blocks and resume explorations
- Inv 4, Part 3, Step 5: Start rolling
- Inv 4, Part 4, Step 4: Start the investigation

### Animals Two by Two Module

- Inv 1, Part 5, Step 5: Go outdoors
- Inv 1, Part 5, Steps 9-10: Go outdoors/Discuss bird sightings
- Inv 2, Part 2, Step 5: Observe shells
- Inv 2, Part 3, Step 8: Observe snail activities
- Inv 3, Part 1, Step 2: Focus question: What are the parts of a redworm?
- Inv 3, Part 3, Steps 2-3: Dig and compare worms
- Inv 4, Part 1, Step 5: Investigate isopod movement and behavior
- Inv 4, Part 3, Steps 3-4: Search for isopods
- Inv 4, Part 2, Step 5: Introduce the race track
- Inv 4, Part 4, Step 1: Focus question: What do animals need to live?
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| Use and share pictures, drawings, and/or writings of observations. | Inv 1, Part 1, Step 12: Reinforce vocabulary  
Inv 1, Part 4, Step 1: Discuss tree shapes  
Inv 1, Part 5, Step 4: Adopt a tree  
Inv 2, Part 1, Step 9: Have a sense-making discussion  
Inv 2, Part 2, Step 5: Observe other shapes  
Inv 2, Part 3, Step 4: Demonstrate the first challenge  
Inv 2, Part 4, Step 6: Have sense-making discussions at centers  
Inv 3, Part 1, Step 9: Share notebook entries  
Inv 3, Part 2, Step 4: Measure the temperature of water  
Inv 3, Part 3, Step 3: Go outdoors  
Inv 3, Part 3, Step 15: Discuss the month’s weather  
Inv 3, Part 3, Step 18: Discuss the weather graph  
Inv 4, Part 2, Step 2: Go outdoors  
Inv 4, Part 5, Step 6: Examine twig cross sections  
Inv 4, Part 8, Step 4: Make bark rubbings |
| Use observations (firsthand or from media) to describe patterns in the natural world in order to answer scientific questions. | Inv 1, Part 1, Step 12: Reinforce vocabulary  
Inv 1, Part 4, Step 1: Discuss tree shapes  
Inv 2, Part 1, Step 9: Have a sense-making discussion  
Inv 2, Part 2, Step 5: Observe other shapes  
Inv 2, Part 3, Step 4: Demonstrate the first challenge  
Inv 2, Part 4, Step 6: Have sense-making discussions at centers  
Inv 3, Part 1, Step 9: Share notebook entries  
Inv 3, Part 2, Step 4: Measure the temperature of water  
Inv 3, Part 3, Step 3: Go outdoors  
Inv 3, Part 3, Step 15: Discuss the month’s weather  
Inv 3, Part 3, Step 18: Discuss the weather graph  
Inv 4, Part 1, Step 1: Introduce the investigation  
Inv 4, Part 3, Step 2: Go outdoors  
Inv 4, Part 5, Step 6: Examine twig cross sections  
Inv 4, Part 8, Step 4: Make bark rubbings |
### Materials and Motion Module

| Inv 1, Part 3, Steps 17–18: Create bar graphs |
| Inv 3, Part 3, Step 6: Test other fabrics |
| Inv 3, Part 4, Step 5: Have a sense-making discussion |

### Animals Two by Two Module

| Inv 1, Part 3, Step 4: Have a sense-making discussion |
| Inv 1, Part 5, Steps 9-10: Go outdoors/Discuss bird sightings |
| Inv 2, Part 1, Step 10: Compare the two water snails |
| Inv 2, Part 2, Step 7: Seriate shells |
| Inv 2, Part 3, Step 6: Return to class |
| Inv 2, Part 3, Steps 18-19: Read and discuss "Water and Land Snails" |
| Inv 3, Part 1, Step 8: Answer the focus question |
| Inv 3, Part 2, Step 18: Have a sense-making discussion |
| Inv 3, Part 3, Steps 2-3: Dig and compare worms |
| Inv 4, Part 1, Step 10: Model responses to the focus question |
| Inv 4, Part 3, Step 7: Discuss the races |

| Inv 1, Part 2, Step 8: Look for patterns with other wood samples |
| Inv 1, Part 15: Go outdoors |
| Inv 1, Part 3, Step 8: Ask questions to guide discussion |
| Inv 1, Part 4, Step 5: Have a sense-making discussion |
| Inv 1, Part 5, Step 8: Have a sense-making discussion |
| Inv 2, Part 1, Steps 4-5: Explan and begin the paper hunt |
| Inv 2, Part 2, Step 7: Have a sense-making discussion |
| Inv 2, Part 2, Step 14: Have a sense-making discussion |
| Inv 2, Part 3, Step 3: Ask questions to guide observations |
| Inv 3, Part 1, Step 11: Begin the fabric hunt |
| Inv 3, Part 3, Step 6: Test other fabrics |
| Inv 3, Part 4, Step 5: Have a sense-making discussion |
| Inv 3, Part 6, Step 9: Observe the effect of sunlight |
| Inv 4, Part 1, Steps 5-7: Introduce/practice rolling |
| Inv 4, Part 2, Step 3: Introduce ramp |
| Inv 4, Part 2, Step 8: Distribute blocks and resume explorations |
| Inv 4, Part 3, Step 5: Start rolling |
| Inv 4, Part 4, Step 4: Start the investigation |

| Inv 1, Part 1, Step 2: Guide observations and discussions |
| Inv 1, Part 2, Step 4: Renew the water |
| Inv 1, Part 3, Step 4: Have a sense-making discussion |
| Inv 1, Part 5, Steps 9-10: Go outdoors/Discuss bird sightings |
| Inv 2, Part 1, Step 4: Compare two types of water snails |
| Inv 2, Part 1, Step 10: Compare the two water snails |
| Inv 2, Part 2, Step 7: Seriate shells |
| Inv 2, Part 3, Step 6: Return to class |
| Inv 2, Part 3, Step 11: Observe snail structures |
| Inv 2, Part 3, Steps 18-19: Read and discuss "Water and Land Snails" |
| Inv 3, Part 1, Step 8: Answer the focus question |
| Inv 3, Part 2, Step 18: Have a sense-making discussion |
| Inv 3, Part 3, Steps 2-3: Dig and compare worms |
| Inv 4, Part 1, Step 10: Model responses to the focus question |
| Inv 4, Part 3, Step 7: Discuss the races |
### Science and Engineering Practices—Grade K

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<tr>
<td>Record information (observations, thoughts, and ideas).</td>
<td>Inv 1, Part 1, Step 4: Go outdoors</td>
</tr>
<tr>
<td></td>
<td>Inv 1, Part 1, Step 7: Conduct more observations</td>
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<tr>
<td></td>
<td>Inv 1, Part 5, Step 4: Adopt a tree</td>
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<td></td>
<td>Inv 4, Part 9, Step 5: Review vocabulary</td>
</tr>
<tr>
<td>Compare predictions (based on prior experiences) to what</td>
<td>Inv 3, Part 3, Step 18: Discuss the weather graph</td>
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<tr>
<td>occurred (observable events).</td>
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<tr>
<td>Use counting and numbers to identify and describe patterns in</td>
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<tr>
<td>the natural and designed world(s).</td>
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<tr>
<td>Display data using simple graphs.</td>
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</table>

**Analyzing and interpreting data**

**Using mathematics and computational thinking**

<table>
<thead>
<tr>
<th>Practices</th>
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<table>
<thead>
<tr>
<th><strong>Materials and Motion Module</strong></th>
<th><strong>Animals Two by Two Module</strong></th>
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<tbody>
<tr>
<td>Inv 2, Part 2, Step 5: Investigate other paper samples</td>
<td>Inv 1, Part 1, Step 2: Guide observations and discussions</td>
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<tr>
<td>Inv 2, Part 3, Step 3: Ask questions to guide observations</td>
<td>Inv 1, Part 5, Step 5: Go outdoors</td>
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<tr>
<td>Inv 3, Part 3, Step 6: Test other fabrics</td>
<td>Inv 2, Part 1, Step 4: Compare two types of water snails</td>
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<tr>
<td>Inv 4, Part 2, Step 8: Distribute blocks and resume explorations</td>
<td>Inv 2, Part 3, Step 8: Observe snail activities</td>
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<td>Inv 3, Part 3, Steps 2-3: Dig and compare worms</td>
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<td>Inv 4, Part 2, Step 3: Look for differences</td>
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<td></td>
<td>Inv 4, Part 3, Steps 3-4: Search for isopods</td>
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<tr>
<td>Inv 1, Part 4, Step 4: Start the investigation</td>
<td>Inv 4, Part 2, Step 5: Introduce the race track</td>
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<tr>
<td>Inv 1, Part 3, Step 17: Create bar graphs</td>
<td>Inv 4, Part 4, Step 1: Focus question: What do animals need to live?</td>
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<tr>
<td>Inv 3, Part 4, Step 5: Have a sense-making discussion</td>
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### Science and Engineering Practices—Grade K

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<thead>
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<th>Practices</th>
<th>Trees and Weather Module</th>
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</thead>
<tbody>
<tr>
<td>Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena.</td>
<td>Inv 1, Part 5, Step 12: Distribute landforms cards&lt;br&gt;Inv 1, Part 6, Step 9: Focus question: What do trees need to grow?&lt;br&gt;<strong>Inv 2, Part 3, Step 9: Focus question: How are leaves different?</strong>&lt;br&gt;Inv 2, Part 5, Step 4: Add descriptions to the pages&lt;br&gt;Inv 3, Part 2, Step 6: Monitor the outdoor temperature&lt;br&gt;Inv 3, Part 3, Step 3: Go outdoors&lt;br&gt;Inv 3, Part 3, Step 8: Provide an engineering challenge&lt;br&gt;Inv 4, Part 9, Step 10: View the video</td>
</tr>
<tr>
<td>Use tools and/or materials to design a device that solves a specific problem or a solution to a specific problem.</td>
<td>Inv 3, Part 2, Step 6: Monitor the outdoor temperature&lt;br&gt;Inv 3, Part 3, Step 3: Go outdoors&lt;br&gt;Inv 3, Part 3, Step 8: Provide an engineering challenge</td>
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<tr>
<td>Make predictions based on prior experiences.</td>
<td>Inv 4, Part 9, Step 10: View the video</td>
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<tr>
<td><strong>Materials and Motion Module</strong></td>
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<tr>
<td>Inv 1, Part 1, Step 14: Have a sense-making discussion</td>
<td>Inv 1, Part 4, Step 4: Have a sense-making discussion</td>
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<tr>
<td>Inv 1, Part 2, Step 15: Go outdoors</td>
<td>Inv 1, Part 5, Step 20: Answer the focus question</td>
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<tr>
<td>Inv 1, Part 3, Step 8: Ask questions to guide discussion</td>
<td>Inv 2, Part 3, Step 13: Have a sense-making discussion</td>
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<tr>
<td>Inv 1, Part 3, Step 19: Add vocabulary to word wall</td>
<td>Inv 3, Part 2, Step 18: Have a sense-making discussion</td>
</tr>
<tr>
<td>Inv 1, Part 6, Step 8: Shape the sawdust wood</td>
<td>Inv 3, Part 3, Steps 2-3: Dig and compare worms</td>
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<tr>
<td>Inv 1, Part 6, Step 13: Answer the focus question</td>
<td>Inv 4, Part 3, Step 7: Discuss the races</td>
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<td>Inv 1, Part 7, Step 5: Discuss the structure of plywood</td>
<td>Inv 4, Part 4, Steps 11-12: Read and discuss “Living and Nonliving”</td>
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<tr>
<td>Inv 2, Part 1, Step 8: Label the classroom</td>
<td>Inv 2, Part 3, Step 6: Have a sense-making discussion</td>
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<tr>
<td>Inv 2, Part 3, Step 11: Go outdoors</td>
<td>Inv 2, Part 5, Step 6: Ask question to guide discussion</td>
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<tr>
<td>Inv 2, Part 4, Step 6: Have a sense-making discussion</td>
<td>Inv 4, Part 2, Step 11: Introduce a design challenge</td>
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<tr>
<td>Inv 2, Part 5, Step 6: Ask question to guide discussion</td>
<td>Inv 4, Part 3, Step 5: Start rolling</td>
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<tr>
<td>Inv 4, Part 2, Step 11: Introduce a design challenge</td>
<td>Inv 4, Part 4, Step 4: Start the investigation</td>
</tr>
<tr>
<td>Inv 4, Part 3, Step 5: Start rolling</td>
<td>Inv 2, Part 1, Step 8: Label the classroom</td>
</tr>
<tr>
<td>Inv 4, Part 4, Step 4: Start the investigation</td>
<td>Inv 2, Part 4, Step 6: Have a sense-making discussion</td>
</tr>
<tr>
<td>Inv 2, Part 5, Step 6: Ask question to guide discussion</td>
<td>Inv 3, Part 2, Step 5: Take apart the burlap</td>
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<tr>
<td>Inv 3, Part 3, Step 5: Sort the materials for recycling</td>
<td>Inv 3, Part 6, Step 9: Observe the effect of sunlight</td>
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<td>Inv 3, Part 6, Step 13: Introduce the design challenge</td>
<td>Inv 4, Part 2, Step 11: Introduce a design challenge</td>
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<tr>
<td>Inv 4, Part 2, Step 11: Introduce a design challenge</td>
<td>Inv 4, Part 3, Step 5: Start rolling</td>
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<td>Inv 4, Part 4, Step 4: Start the investigation</td>
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## Science and Engineering Practices—Grade K

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<td>Construct an argument with evidence to support a claim.</td>
<td>Inv 1, Part 1, Step 16: Engage in argument from evidence</td>
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<td></td>
<td>Inv 2, Part 2, Step 10: Share notebook entries</td>
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<tr>
<td>Read grade-appropriate text and/or use media to obtain scientific and/or technical information to describe patterns in the natural world.</td>
<td>Inv 2, Part 5, Step 6: Read <em>Our Very Own Tree</em></td>
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<td>Inv 3, Part 1, Step 11: Discuss the reading</td>
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<td>Inv 3, Part 3, Steps 9-10: Read “Weather” and discuss the reading</td>
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<tr>
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<td>Inv 4, Part 2, Steps 7-8: Read “My Apple Tree” and have a sense-making discussion</td>
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<td>Inv 4, Part 4, Steps 8-9: Read “Orange Trees” and discuss seasons and trees</td>
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<td>Inv 4, Part 6, Step 7: View the video on sugar maple trees</td>
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<td>Inv 4, Part 9, Step 10: View the video</td>
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<tr>
<td>Communicate information or solutions with others in oral and/or written forms using models and/or drawings that provide detail about scientific ideas.</td>
<td>Inv 1, Part 5, Step 12: Distribute landforms cards</td>
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<td><strong>Inv 1, Part 6, Step 11: Have a sense-making discussion</strong></td>
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## Materials and Motion Module

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<td>Inv 1, Part 1, Steps 20-21: Read “The Story of a Chair” and discuss</td>
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<tr>
<td>Inv 4, Part 1, Steps 16-17: Read and discuss “Pushes and Pulls”</td>
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<tr>
<td>Inv 4, Part 2, Steps 16-17: Read and discuss “Collisions”</td>
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## Animals Two by Two Module

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<th>Activity Description</th>
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<tbody>
<tr>
<td>Inv 2, Part 3, Step 23: Engage in science talk</td>
</tr>
<tr>
<td>Inv 3, Part 3, Step 14: Share notebook entries</td>
</tr>
<tr>
<td>Inv 1, Part 4, Step 10: Share information about photos</td>
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<tr>
<td>Inv 1, Part 4, Steps 11-12: Read and discuss “Fish Live in Many Places”</td>
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<tr>
<td>Inv 1, Part 5, Steps 21-22: Read and discuss “Birds Outdoors”</td>
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<tr>
<td>Inv 3, Part 3, Steps 10-12: Read and discuss “Worms in Soil”</td>
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<td>Inv 4, Part 2, Steps 10-12: Read and discuss “Isopods”</td>
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<tr>
<td>Inv 4, Part 3, Steps 11-13: Read and discuss “Animals All around Us”</td>
</tr>
<tr>
<td>Inv 4, Part 4, Step 13: Read and discuss <em>Animals Two by Two</em></td>
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