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).
Science and Engineering Practices—Grade 3

NOTE
Appendix F of NGSS identifies capabilities of students using practices at each grade band. We have put those capabilities that appear in the performance expectations for grade 3 in bold face. These capabilities describe what students should be working toward in the grade band. The strategies shared in this chapter are designed with these capabilities in mind.

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 3–5 grade band. Those in bold are emphasized in grade 3 based on the NGSS performance expectations.

1. Asking questions and defining problems
   • Ask questions about what would happen if a variable is changed.
   • Identify scientific (testable) and non-scientific (non-testable) questions.
   • Ask questions that can be investigated based on patterns such as cause-and-effect relationships.
   • Use prior knowledge to describe problems that can be solved.
   • Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.

2. Developing and using models
   • Identify limitations of models.
   • Collaboratively develop and/or revise a model based on evidence that shows the relationships among variables for frequent and regular occurring events.
   • Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution.
   • Develop or use models to describe and predict phenomena.
   • Develop a diagram or simple physical prototype to convey a proposed object, tool, or process.
   • Use a model to test cause-and-effect relationships or interactions concerning the functioning of a natural system.

3. Planning and carrying out investigations
   • Plan and conduct an Investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.
   • Evaluate appropriate methods and/or tools for collecting data.
• Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or to test a design solution.
• Make predictions about what would happen if a variable changes.
• Test two different models of the same proposed object, tool, or process to determine which better meets criteria for success.

4. **Analyzing and interpreting data**
• Represent data in tables and/or various graphical displays (bar graphs, pictographs [and/or pie charts]) to reveal patterns that indicate relationships.
• Analyze and interpret data to make sense of phenomena using logical reasoning.
  • Compare and contrast data collected by different groups in order to discuss similarities and differences in their findings.
  • Analyze data to refine a problem statement or the design of a proposed object, tool, or process.
  • Use data to evaluate and refine design solutions.

5. **Using mathematics and computational thinking**
• Decide if qualitative or quantitative data are best to determine whether a proposed object or tool meets criteria for success.
• Organize simple datasets to reveal patterns that suggest relationships.
• Create and/or use graphs and/or charts generated from simple algorithms to compare alternative solutions to an engineering problem.

6. **Constructing explanations and designing solutions**
• Construct an explanation of observed relationships (e.g., the distribution of plants in the backyard).
• **Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem.**
  • Identify the evidence that supports particular points in an explanation.
  • Apply scientific ideas to solve design problems.
  • Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.

**References**


7. Engaging in argument from evidence

- Compare and refine arguments based on an evaluation of the evidence presented.
- Distinguish among facts, reasoned judgment based on research findings, and speculation in an explanation.
- Respectfully provide and receive critiques from peers about a proposed procedure, explanation, or model by citing relevant evidence and posing specific questions.
- Construct an argument with evidence, data, and/or a model.
- Use data to evaluate claims about cause and effect.
- Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.

8. Obtaining, evaluating, and communicating information

- Read and comprehend grade-appropriate complex texts and/or other reliable media to summarize and obtain scientific and technical ideas and describe how they are supported by evidence.
- Compare and/or combine across complex texts and/or other reliable media to support the engagement in other scientific and/or engineering practices.
- Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem.
- Communicate scientific and/or technical information orally and/or in written formats, including various forms of media, such as tables, diagrams, and charts.

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.

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.

<table>
<thead>
<tr>
<th>SEP Focus</th>
<th>Water and Climate Module</th>
<th>Motion and Matter Module</th>
<th>Structures of Life Module</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asking questions and defining problems</td>
<td></td>
<td>Inv 2, Part 4, Step 7: Develop questions for designing an investigation</td>
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<tr>
<td>Developing and using models</td>
<td>Inv 1, Part 1, Step 13: Answer the focus question</td>
<td>Inv 3, Part 5, Step 7: Introduce the condensation chamber</td>
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<tr>
<td>Planning and carrying out investigations</td>
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<td>Analyzing and interpreting data</td>
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<td>Inv 4, Part 2, Step 11: Have a sense-making discussion</td>
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<tr>
<td>Obtaining, evaluating, and communicating information</td>
<td></td>
<td>Inv 1, Part 1, Step 21: Have a sense-making discussion</td>
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</tbody>
</table>

Grade-level examples for practices described in this chapter.

For example, a strategy called “put in your two cents” can be used for developing an argument to determine whether or not a seed is a living organism. In other cases, the teacher will need to decide how best to advance student capabilities. This can be through a series of questions and frames or through mini-lessons. 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 in these practices.

### 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. For example, “When I think about planning an investigation, I think about which Step I should take first and write that down. 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 missing significant details. For example, when setting up tests to determine if crayfish are territorial, provide a procedure that does not include recording the locations of the crayfish. Students can provide feedback on the example before using the practice themselves. Additionally, two uses or examples of the practice can be placed next to each other for students to compare.

<table>
<thead>
<tr>
<th>Procedure A</th>
<th>Procedure B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Put one house in each corner of the tub of crayfish.</td>
<td>1. Put houses in the tub.</td>
</tr>
<tr>
<td>2. Observe the crayfish right after lunch.</td>
<td>2. Mark each of the crayfish and give them names.</td>
</tr>
<tr>
<td>3. Record where the crayfish are in our notebook.</td>
<td>3. Observe the crayfish right after lunch.</td>
</tr>
<tr>
<td></td>
<td>3. Record where each crayfish is in our notebook.</td>
</tr>
</tbody>
</table>

Two partial procedures provided by the teacher for students to critique
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. Students’ initial questions may not be formalized into guiding questions that will lead to uncovering essential truths about the natural world. Student actions with materials are usually cause-and-effect questions, such as “What happens when I move the magnet closer to the paper clip?” Students might need guidance to connect these procedures with questions that can be investigated. For example, when students are testing different wheels on a cart design, the teacher might say, “It looks like you are changing a variable on your cart. You are trying to find out how larger wheels affect how far the cart rolls.” Other questions, such as “Why is the cart wheel 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 conducting investigations, continuing the process. Questions about phenomena 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 encounter secondary problems they need to solve. Defining both the overarching problem as well as solutions to the 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 those questions. When students ask questions, the teacher sorts those questions (in their head) into four categories and then takes appropriate action.

Appendix F of NGSS identifies student capabilities as they ask questions and define problems. Those in bold appear in the performance expectations for grade 3.

- Ask questions about what would happen if a variable is changed.
- Identify scientific (testable) and non-scientific (non-testable) questions.
- Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause-and-effect relationships.
- Use prior knowledge to describe problems that can be solved.
- Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.
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 3

In the Motion and Matter Module, Investigation 2, Part 4, students explore tops and begin to adjust the variables and observe the effects on the spin. During Step 7, a class list of questions are generated. In this example, the teacher wants to support students in developing questions as this is her first module in the year. The teacher uses an instructional strategy to help students ask questions about what would happen if a variable is changed. After exploration time, the teacher facilitates a discussion with students. The teacher asks students what are the parts of the top that can be changed? and how can they be changed? For example, the placement of a large, red disk could be at the top, middle, or bottom of the shaft. Taking this variable, the teacher can rephrase this as a cause-and-effect question, such as, “How does the placement of the red disks on the shaft affect how long the top will spin?” After recording this question on the board or in a class notebook, students can work in groups to develop other questions about different variables using a similar sentence frame. Examples of questions student might ask are,

- What is the best design for a top that spins a long time?
- What is the best design for a top that spins fast? Spins slowly?
- Does it make a difference if you use the big or small disks?
Alternatively, questions could focus on a desired effect as often is the case in engineering, for example, “What design will have the longest spin?”

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

**Identify scientific (testable) and non-scientific (non-testable) questions.** Work with students to generate a list of questions after a common experience with a phenomenon. These questions should be written on the board or on sentence strips. Have a discussion about which are testable questions and which are not. For example, a question in which a variable is changed and can be measured is a testable question. A question about why an axle is green is not one students can test. Consider what to do with questions that are testable by scientists safely or questions that could be tested if certain materials or conditions are present.

**Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause-and-effect relationships.** Strategies for the first Part of this capability are shared above. Having students predict reasonable outcomes requires recognition and application of patterns resulting in cause-and-effect relationships. (See the Crosscutting Concepts chapter for strategies.) Once those patterns and relationships have been identified, model a sentence frame for predicting such as, I think ______ will happen when ______.

**Use prior knowledge to describe problems that can be solved.** Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. 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. As the criteria and constraints are introduced, again have students rephrase these in their own words. These problems, criteria, and constraints can be recorded on a piece of chart paper throughout design process.

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

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

Here are other examples of asking questions and defining problems in FOSS grade 3 modules.

- In the Water and Climate Module, students ask questions that could be tested about how water and earth materials interact.
- In the Motion and Matter Module, students ask questions about how magnets interact with other magnets and paper clips; about other forces at work in the natural world.
- In the Structures of Life Module, students ask questions about plant growth and development.
Science and Engineering Practices—Grade 3

- 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 ______. 
- Based on what I know about ______ I think ______.

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

- Which of these questions are you wondering about? 
- Which variable do you want to change? 
- Could ______ be the problem? 
- Is ______ a criterion? 
- Could ______ be a constraint? 
- What questions do you have about ______? 
- What questions do you have about the variables? 
- What questions could you ask to find out ______? 
- What would be an alternative question? 
- What is the problem we are trying to solve? 
- What are the criteria? What are the constraints?
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, test their ideas about cause-and-effect relationships, and make predictions. While models help students think about specific systems, they need to be aware of their limits such as what they describe or how they differ from the principle they represent.

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 predictions based on their models reveal if and how they are making connections between effects and their causes. The teacher can ask questions or provided 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 discuss their ideas during data collection. Questions such as, “How does that work?” and “What would the effect be if you added another magnet?” will prompt students to change variables and collect additional data. 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. The general idea is for students to develop their own models based on data analysis and discourse and to improve them through instruction, collaboration, and reasoning.

Examples in Grade 3

In the Water and Climate Module, Investigation 1, Part 1, students develop a model to explain what happens when water comes in contact with different materials. In this example, the teacher chooses a strategy to support students develop their model and then use it to predict cause-and-effect relationships with other surfaces. In developing a...
model, the teacher has students generate a list of parts to include, such as different types of surfaces, what happens when the water beads up or absorbs, and an explanation of how the surface absorbs or does not absorb water. Students create a group model initially, share that group model with another group, and revise their model based on peer feedback. The teacher provides a new surface, such as a red plastic disk (used during Investigation 4). Students compare the properties of the new surface to those in their model and discuss if water would or would not be absorbed.

Later in the Water and Climate Module, Investigation 3, Part 5, Step 7, students develop and use a condensation chamber to observe the phenomenon of condensation. The teacher uses a strategy to help students identify the limitations of this model. The teacher has students discuss how the condensation chamber might be a good model as indicated in Step 7. Afterwards, the teacher shares how scientists will not include everything in their model so they can explain a specific phenomenon. Student discuss what the condensation chamber shows and what it does not show. For example, the condensation chamber has only water in it, but Earth also has land and living organisms. These limitations are recorded in the class notebook. When students have a sense-making discussion in Step 21, additional limitations can be added.

**Other strategies for developing and using models.**

Collaboratively develop and/or revise a model based on evidence that shows the relationships among variables for frequent and regular occurring events. As students work with cause-and-effect relationships, they are able to develop or revise models based on these relationships. Provide opportunities for students to work in a group to support the development of a model. Use specific strategies for partner discussion (see the Science-Centered Language Development chapter for more information) so students are provided with peer feedback on their models.

Additionally, provide a partially developed model for the class to critique and revise based on their understanding of the variables. A partial model might include one variable, but not explain changes to the variable and the impact of those changes. Think-alouds also provide insight into ways to make revisions to models for students.

Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution, develop and/or use models to describe and/or predict phenomena, and develop a diagram or simple physical prototype to convey a proposed object, tool, or process.
In the development and use of a model, students describe principles, phenomena and aspects of engineering. Using the FOSS program promotes the development of these models through experience and sense-making discussions. To further support student models, have a discussion asking students to generate a list of what needs to be incorporated into their model, such as a drawing of a particular system, or the causes and effects when variables are changed. Have students use this list to critique their own models and make revisions.

Use a model to test cause-and-effect relationships or interactions concerning the functioning of a natural or designed system. After students have developed a model, ask students to consider the effects when a variable is changed within the system under study. For example, after students developed a model about water interacting with different surfaces, have them consider what would happen if the amount of water increased from a few drops to a bucket or what the effect of using a different surface, such as sand paper, would have on water. Allow students time to refine their model as necessary.

Sentence frames for students to use to develop and use models.

- The model shows/explains/predicts _____ .
- The model doesn’t explain _____ .
- The parts of my model are _____ .
- I revised my model based on _____ .
- My model shows how _____ affects _____ .

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 does the model explain? What doesn’t it explain?
- What is the relationship between _____ and _____ ?
- 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 3 modules.

- In the Water and Climate Module, students develop and use models to describe how the processes of evaporation and condensation work.
- In the Motion and Matter, Module, students develop and use models to describe their thinking about how magnets interact with each other and with paper clips, describing the invisible magnetic field and how it acts.
- In the Structures of Life Module, students develop models of articulated skeletons and compare the functioning of the model to the actual skeleton.
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 third grade have some experience in carrying out investigations often suggested or guided by teachers. These experiences serve as a starting point for students and teachers. When investigating phenomena, a teacher needs to consider the allocation of time, the level at which students can plan and conduct independently, and what skills students can develop during the lesson. In the Investigations Guide, a procedure might be provided for everyone to follow when controlling variables for the first time. Later in the module, students might develop their own procedures. Teachers will need to adjust their expectations to the skill and experience of their students. Similarly, instructions on how to use measurement 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 can be recorded on a provided notebook sheet or students can develop their own recording method. Again, the teacher needs to determine the time available and the prior experience of students. See the Science Notebooks in Grades 3–5 chapter for more strategies for acquiring data.

Example in Grade 3

In the Motion and Matter Module, Investigation 2, Part 2, Steps 8–9, students are challenged to make a two-cup system roll straight down a ramp. The materials are controlled for students, two identical paper cups, a penny, and some tape. In this example, the teacher wants students to test two different models of the two-cup design and determine which rolls straight. As students begin, some...
tackle this using a trial and error method. This might seem haphazard—
students are comparing two designed systems—the one previously
tested and the one they just modified. The teacher visits with each
group and asks if the modification results in a roll that is straighter than
the previous roll. Based on the student observations, the group needs to
determine if the new design is deemed an improvement or if a different
design is needed. The teacher can move from group to group to check
for systematic testing, asking probing questions such as, “How do you
know if the design is meeting the criteria?” or “Your system keeps
turning to the left, what does that tell you about your design?”

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

Plan and conduct an Investigation collaboratively to produce
data to serve as the basis for evidence, using fair tests in which
variables are controlled and the number of trials considered.
Many investigations in FOSS have indicated steps for students to use to
produce data. Some of these have prepared notebook sheets with those
steps listed along with materials and a data collection tool. These can
serve as resources for students to reference when developing their own
methods. A teacher might say, “Let’s look back at the procedure we
used for <previous investigation>. If we want to make our own plan,
what would we need to do?”

Additionally, hold a class discussion and ask students what steps should
be included in a procedure. These are collected on the board and
placed in the correct order by class consensus. Illustrations can be
provided for each Step as well.

Evaluate appropriate methods and/or tools for collecting data.
As students develop proficiency with data collection methods and tools,
allow students to create their own tools, similar to notebook sheets used
previously. During their use, ask students how useful the tool (table,
chart, narrative, etc.) is. Student-generated tools can serve as models for
other students with the creator explaining their use.

To evaluate data-collection systems, competing methods can be
demonstrated by the teacher. Ask students which method is more
accurate and why.

Make observations and/or measurements to produce data
to serve as the basis for evidence for an explanation of a
phenomenon or test a design solution. Many FOSS investigations
have students making observations and taking measurements. These
skills can be improved by using mini-lessons, examples/nonexamples, or
having students model appropriate techniques.

*Science and Engineering Practices—Grade 3*
Make predictions about what would happen if a variable changes. Closely related to the crosscutting concepts of cause and effect and patterns, making predictions about outcomes is a skill that can be developed in many investigations. After students have a common experience in which a cause-and-effect relationship or pattern is determined, discuss how one variable can be changed, such as increasing the amount of water dropped on a surface. Initially, have students share all of the possible outcomes before making a prediction, such as, the greater the amount of water might 1. Increase the speed it goes downhill. 2. Decrease the speed. 3. Not change the speed. This provides students an opportunity to focus their prediction. As students increase their proficiency, decrease the amount of scaffolding provided and begin to ask students to provide a reason for their prediction using a frame such as, “I think ________ will happen because ________.”

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 _____.
- Based on what I know about _____, we predict _____.
- If we _____, we expect _____.

Here are other examples of planning and carrying out investigations in FOSS grade 3 modules.

- In the Water and Climate Module, students plan and carry out investigations to determine the temperature of water, what happens to the temperature of hot and cold water when they mix, and where an animal can go to stay warm (in cold weather) or stay cool (in warm weather).

- In the Motion and Matter Module, students plan and carry out investigations with mixtures of solids and solids, and solids and liquids.

- In the Structures of Life Module, students plan and carry out investigations dealing with crayfish behavior.
Questions for teachers to ask students about planning and carrying out investigations.

• Are you trying to find out _____?
• Have you considered _____?
• What will you do first? Second?
• Will you need _____?
• Is this the variable you will control?
• 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 could you determine _____?
• Which variables are controlled?
• How will you test _____?
• How will you know if _____ meets the criteria?
• Is there anything else you want to find out?
Science and Engineering Practices—Grade 3

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 Notebooks in Grades 3–5 chapter discusses strategies for guiding students towards independent 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 3

In the Structures of Life Module, Investigation 4, Part 2, Steps 9 and 11, students observe the bones found in an owl pellet. After they make observations, students make drawings of these bones in their notebooks, comparing them to human bones. These drawings serve as an organized visual display to determine similarities and differences. In this example, the teacher focuses the sense-making discussion on the visual displays, having students make drawings in the class notebook to answer the questions.
• How are these animal bones similar to human bones?
• How are these animal bones different from human bones?
• What can bones tell us about how the animals moved, what it ate, and how it lived?

This analysis of the bones during the sense-making can reveal patterns about the functions of bones such as structure and protection.

**Other strategies for analyzing and interpreting data.**

Represent data in tables and/or various graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships. When a new graphical display is being introduced, model how to transfer or transform the data as well as describe why this display is useful. Many of these displays should be incorporated into the class notebook initially by the teacher, and then by students.

Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation, compare and contrast data collected by different groups in order to discuss similarities and differences in their findings, analyze data to refine a problem statement or the design of a proposed object, tool, or process and use data to evaluate and refine design solutions. In the *Investigations Guide*, each Part contains steps in which questions are asked to share data and guide the analysis and interpretation of data in order to construct explanations or design solutions. These steps are often identified as a sense-making discussion. For more information, see the Sense-Making Discussions for Three-Dimensional Learning chapter.

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

• My data show ______.
• My data show a pattern; I see ______.
• ______ and ______ are similar because they both ______.
• ______ and ______ are different because ______.
• From the data, I can infer that ______.

Here are other examples of analyzing and interpreting data in FOSS grade 3 modules.

• In the **Water and Climate Module**, students analyze and interpret data to compare forecasts and compare the data to what was actually observed and determine the variables involved in evaporation (surface area and temperature).
• In the **Motion and Matter Module**, students analyze and interpret data to make sense of cause-and-effect relationships, using twirly birds.
• In the **Structures of Life Module**, students analyze and interpret data to compare the number of seeds found in a pod of one kind of fruit in order to reveal patterns that can be used to make predictions.
Science and Engineering Practices—Grade 3

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

- Is there a pattern here?
- Are these the same or different?
- Can you organize the data by _____?
- Can you make a diagram to show _____?
- If you change _____, will that improve the design?
- How is _____ related to _____?
- How does _____ compare to _____?
- How will you organize these data?
- Based on the data, how will you change your design?
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, “What information do we need to answer the question?” and “What can we measure or estimate?” are useful for students to consider. Quantitative data (things counted or measured) can be displayed in various ways for analysis.

Strategies for asking questions and defining problems.

Decide if qualitative or quantitative data are best to determine whether a proposed object or tool meets criteria for success. While most data collection methods on the success of designs are provided for students, a discussion about how to collect and analyze data is appropriate as students’ skills progress. Instead of using a provided method, ask students what kinds of data are needed to determine if their design is successful.

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

- Our results are _____.
- The graph/table shows _____.
- We measured _____.
- Based on _____, the results show _____.
- We measured _____ in order to _____.
- We use math to _____.

Appendix F of NGSS identifies student capabilities as they use mathematics and computational thinking. None of these appear in the performance expectations for grade 3.

- Decide if qualitative or quantitative data are best to determine whether a proposed object or tool meets criteria for success.
- Organize simple data sets to reveal patterns that suggest relationships.
- Describe, measure, estimate, and/or graph quantities (e.g., area, volume, weight, time) to address scientific and engineering questions and problems.
- Create and/or use graphs and/or charts generated from simple algorithms to compare alternative solutions to an engineering problem.
Here are examples of using mathematics and computational thinking in FOSS grade 3 modules.

- In the **Water and Climate Module**, students use mathematics and computational thinking to calculate how much water a dry sponge can soak up.

- In the **Motion and Matter Module**, students use mathematics and computational thinking to reveal patterns of magnetic interactions at a distance (magnets and paper clips).

- In the **Structures of Life Module**, students use mathematics and computational thinking to determine the resulting population of insects after five generations in a specific environment.

Questions for teachers to ask students about using mathematics and computational thinking.

- What does the graph (table) tell you?
- Would _____ represent this pattern?
- Is this a way to show _____?
- Do the data mean that _____?
- Does the change in _____ mean that _____?
- What does this represent?
- What can you organize in a graph or table?
- How would you organize _____ to show _____?
- Did number patterns help us understand what is going on?
- Do the numbers support your explanation?
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 related to phenomena are cause-and-effect relationships, such as, “How does surface area affect evaporation?” When explaining the phenomenon of a cause-and-effect relationship, students should use claim, evidence, and when appropriate, reasoning. The claim, what students believe to be true about the relationship, needs to be supported with evidence, collected data that supports the claim. When appropriate, a model-based reason might be incorporated into the explanation. While reasoning is developed in middle school, there are opportunities when elementary students can 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.

Example in Grade 3

In the Motion and Matter Module, Investigation 4, Part 1, Step 9, students make three mixtures: gravel and water, powder and water, and salt and water, and observe the results. In making these observations, students determine that different outcomes happen depending on what is mixed together. In this example, the teacher wants to develop students’ capability in constructing an explanation and using evidence towards the beginning of the year. During the sense-making discussion, the teacher asks students to make a statement about what happens when solids combine with water. The students report their observations as

Appendix F of NGSS identifies student capabilities as they construct explanations and design solutions. Those in bold appear in the performance expectations for grade 3.

- Construct an explanation of observed relationships (e.g., the distribution of plants in the backyard).
- Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem.
- Identify the evidence that supports particular points in an explanation.
- Apply scientific ideas to solve design problems.
- Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.

See the Motion and Matter Module, Investigation 4, Part 1, Step 9 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 constructing explanations.
indicated in Step 9. In order for students to generate a claim, the teacher asks if the same thing always happens when a solid is mixed with water. Students are provided with a sentence frame, such as, “When solids and water are mixed, _____.” to elicit the claim. The teacher writes this frame in the class notebook, asks a student to complete the statement, and identifies the statement as a claim. A second sentence frame is then provided, such as “The data that supports this is _____.” Students cite the three different observations they made to support their claim. These are also written in the class notebook, and the teacher identifies these specific pieces of data as evidence.

**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 sentence frames, and allow time for revision. During discussions, teachers should listen for claims and evidence and use clarifying the 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 as well. These broader explanations connect to the Disciplinary Core Ideas and the natural or designed world.

**Other strategies for constructing explanations and designing solutions.**

Construct an explanation of observed relationships (e.g., the distribution of plants in the backyard) and Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem. During the sense-making discussion, data are analyzed, relationships and patterns are determined. In cause-and-effect relationships, students can make
a claim based on the analysis of data. This can be done by providing language frames for students. At the beginning of the year, claims might be developed during the sense-making discussion as a class. Data to support the claim can also be discussed during the sense-making discussion. Once data have been selected to support a claim, they advance to the status of evidence. Often for third graders, guidance can be provided as sentence frames in the class notebook. Multiple pieces of evidence are recommended in a well-developed explanation. Having students label different pieces of evidence with numbers can serve as a reminder to incorporate sufficient evidence.

**Identify the evidence that supports particular points in an explanation.** Helping students identify data to support a claim or identify evidence in an already created claim can be done in a few ways. In providing evidence, students may not recognize which data to include while others might include all data. As students share observations, write these on a piece of chart paper and cut out each observation for the class to sort these into data supporting their claim and data that do not pertain or relate to the claim. When identifying evidence in an explanation, first have students state the claim being made. This can be done by having students highlight or underline it in a certain color. Guide students to identify the first item of evidence being used and underline it in another color. Have students work with a partner or individually to identify all evidence in the explanation.

**Apply scientific ideas to solve design problems.** 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 to 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. If there are particular patterns, rules, or relationships that are pertinent, make sure they are brought forward. Ask students how these scientific concepts could help their design. If some students’ design is already incorporating these ideas, consider having them share their progress.

**Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.** 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...
Here are other examples of constructing explanations and designing solutions in FOSS grade 3 modules.

- In the **Water and Climate Module**, students construct explanations using evidence to explain how the properties of different kinds of soil promote or impede drainage or to evaluate the design of a waterwheel, based on the criteria of the number of syringes of water to lift a load 1 meter.

- In the **Motion and Matter Module**, students construct explanations based on their data from moving carts.

- In the **Structures of Life Module**, students construct explanations based on their data when monitoring plant growth.

and constraints. Depending upon classroom culture, comparisons can be made among groups, however, be sure to keep the focus on discussing the benefits and limitations of the designs, not creating a competition.

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

- I observed _____ .
- I think _____ because _____ .
- We think _____ is the best solution because _____ .
- Based on _____ , I think _____ .
- The relationship between _____ and _____ shows that _____ .
- The evidence to support _____ is _____ .
- There is a pattern that shows _____ .
- Both these solutions _____ ; however, _____ is better because _____ .
- What evidence do you have that _____ ?

**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. 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.

**Strategies for engaging in argument from evidence.**

Compare and refine arguments based on an evaluation of the evidence presented. Critique two arguments. Present two arguments on the board, both containing evidence from students’ collected data. One should contain sufficient evidence to support the claim. The other should have a credible claim, but insufficient evidence or irrelevant data. Or it could be a claim that is not supported or connected to the evidence presented.
Ask students to identify the claim and evidence in both arguments. Have them discuss which has better evidence supporting the claim. Question them about how the evidence supports the claim. Have students work with a partner to refine the other position to incorporate stronger evidence.

**Distinguish among facts, reasoned judgment based on research findings, and speculation in an explanation.** Consider the level of the concepts and determine which are widely accepted facts, which are still developing concepts, and which are typical speculations that students might be tempted to promote as explanations. These facts, judgments, and speculations might appear as students’ claims during discussion or in writing. Teasing these out helps students learn the importance of developing valid, robust claims and evidence.

**Sorting sentences.** Write several facts, judgments, and speculations on sentence strips, such as

- Crayfish are animals.
- Crayfish use swimmerets for movement in the water.
- Male crayfish are bigger than females.

Put one fact, one judgment, and one speculation on the board. Ask students to describe how each statement differs from the others. Guide the discussion with questions.

➤ *Are there any statements that we all agree are true?* [Identify these types of statements as facts.]

➤ *Which statement do we think is probably true based on the work we have done?* [Judgments based on research findings.]

➤ *Which statements seem like they might be possible but are not supported by evidence?* [Speculations.]

Give students more statements to be sorted into facts, judgments, and speculations:

- Crayfish have claws. [Fact.]
- Crayfish are territorial. [Judgement.]
- Crayfish eat each other when they don’t have enough room to hide from each other. [Speculation.]

**Respectfully provide and receive critiques from peers about a proposed procedure, explanation, or model by citing relevant evidence and posing specific questions.** When discussing explanations, students critique the work of fellow classmates. Initially,
guide the process to ensure students honor norms for discourse and to make sure that all students participate. As the year progresses, the discussions should be managed by students with minimal guidance.

A/B partners. Use a discussion protocol, such as A/B partners, to pair students who will critique each other’s procedures, explanations, or models. Assign partners with divergent positions. Have student A share his or her thinking while student B listens. Student B responds by asking clarifying questions like these.

➤ Why did you decide to put those seeds here?
➤ What happens if you increase the height?
➤ How does your model explain the effect of atmospheric pressure on the crushed bottle?

Poster sharing. Have groups write their procedure, explanation, or model on chart paper and hang the posters around the room. Groups visit other posters with self-stick notes and pencils in hand. As they read the posters, they write questions such as “What is your evidence?” or “What does this Part of the model show?” Groups return to their own posters and edit their original thinking, based on peer feedback.

Construct and/or support an argument with evidence, data, and/or a model. In FOSS, students provide written explanations when answering focus questions. These explanations can be refined through argumentation. During discussion, students might present their arguments orally. In both instances, students should provide evidence, data, and models for their arguments.

Revision with color. When students begin to engage in argument, their argument will need development. One strategy is to have students write their argument and then identify and color-code portions of their arguments. For example, they can underline their claim in one color and evidence statements with another color. More sophisticated arguments might need a third color to underline the description of a model. Color-coding can help students identify aspects of their constructed argument and determine if any elements are missing or need refinement. Another variation is to have students add new information using one color and correct information in another.

Four corners. Choose two or more claims or explanations about a particular phenomenon. Write each claim at the top of a poster. Divide the poster in half with a vertical line and write “statements in support” on one side and “statements against” on the other. Hang the posters around the room and divide the class into groups. Have each group go to one poster. The group reads the claim and agrees or
disagrees with it. The group provides thoughts, evidence, or models to support their stance. They could also come up with statements taking the other point of view and add those to the poster.

Groups rotate through each of the posters, evaluating the different claims. After visiting all the posters, groups can review the statements for and against each claim. Ask questions to nudge the thinking toward the best representation of the fundamental knowledge offered by the investigation. Students then revisit their own arguments. They can refine their thinking about the topic by adding their arguments, including models, to their science notebooks.

**Use data to evaluate claims about cause and effect.** When examining cause-and-effect claims, students need to process data from experience or information (from reliable text) to determine whether the claim is valid.

Multiple corners. Write three or four different cause-and-effect statements on a piece of chart paper. Use claims from student work that identify common understandings. Here are some examples.

1. The higher the starting position of a cart on a ramp, the farther the cart will travel.
2. The lower the starting position of a cart on a ramp, the farther the cart will travel.
3. The cart will always travel the same distance no matter where the cart starts.

Post each claim in a different corner of the room. Assign an even number of students to each claim. In the first round, have students write two points of data under the claim that support or refute the claim. They should not identify whether the data support or refute the claim. The groups then rotate to a different claim. In the second round, students verify that the data posted accurately represent the class findings and write “Supports” or “Refutes” next to the data. The groups rotate one more time and edit the claim for accuracy or revise the claim to represent available information.

**Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.** In designing and engineering a solution to a problem, students consider the criteria and constraints framing the solution to the problem. When evaluating a solution, they use evidence to declare success or to head back to the drawing board.

Student-generated checklist. Begin a class discussion by asking for one criterion that defines a satisfactory solution to a particular problem and
write it on the board. Ask for examples of what meets that particular criterion and what does not meet it. Students help identify evidence that will determine the merits of a solution. Repeat this process for additional criteria for acknowledging constraints. Once students have created this checklist, ask them to consider the proposed solution. Ask students to identify the evidence for the first criteria or constraint on the checklist: “Does the evidence meet the criterion or not?” Encourage students to work in pairs on their checklist. To wrap up, ask the pairs to make a claim about the merit of the solution and to provide evidence to support their claim.

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 models show ______.
- My data show ______.
- Based on ______, I would argue that ______.
- Have you considered ______?
- I agree/disagree that ______ causes ______ because ______.
- ______ meets the criteria because it ______.

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

- Do you agree or disagree?
- Do you think ______ supports the idea that ______?
- Which piece of evidence supports the claim ______?
- Why do you think that is so ______?
- What is your evidence?
- Please explain why you disagree that ______.
- Why do you think ______ supports the idea that ______?

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

- In the **Water and Climate Module**, students engage in argument from evidence concerning the processes of evaporation and condensation.
- In the **Motion and Matter Module**, students engage in argument from evidence about the reasons for the relationship between the height of the starting position on the ramp and the distance a cart travels.
- In the **Structures of Life Module**, students engage in argument from evidence about the social behavior of crayfish.
Appendix F of NGSS identifies student capabilities as they obtain, evaluate, and communicate information. Those in bold appear in the performance expectations for grade 3.

- Read and comprehend grade-appropriate complex texts and/or other reliable media to summarize and obtain scientific and technical ideas and describe how they are supported by evidence.

- Compare and/or combine across complex texts and/or other reliable media to support the engagement in other scientific and/or engineering practices.

- Combine information in written text with that contained in corresponding tables, diagrams, and/or charts to support the engagement in other scientific and/or engineering practices.

- Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem.

- Communicate scientific and/or technical information orally and/or in written formats, including various forms of media as well as tables, diagrams, and charts.

### 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’ firsthand experiences combined with the science and engineering practices are extended by engaging with texts and other sources of information. Skills are 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 firsthand 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 3.**

In the Structures of Life Module, Investigation 1, Part 1, Step 21, students observe the seeds from many different types of fruits. 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 seeds for students to answer as they read. As students read the text, they determine answers to their questions. During the sense-making
discussion in Step 21, 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.**

Read and comprehend grade-appropriate complex texts and/or other reliable media to summarize and obtain scientific and technical ideas and describe how they are supported by evidence, compare and/or combine across complex texts and/or other reliable media to support the engagement in other scientific and/or engineering practices and obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem. The articles in the *FOSS Science Resources* book provide complex texts and FOSSweb provides other media sources that are connected specifically to the concepts they explored. After having a sense-making discussion, students have an understanding of concepts before reading articles and interacting with media. Specific strategies are shared within the *Investigations Guide* and the Science-Centered Language Development chapter for articles and various media. Additionally, pictorials and guided writing can be done with students in the class notebook connecting students’ ideas previously discussed to those obtained from texts. Specifically, students should consider evidence from the text to support their responses to the focus questions or similar claims.

Combine information in written text with that contained in corresponding tables, diagrams, and/or charts to support the engagement in other scientific and/or engineering practices. As indicated above, strategies for obtaining information from text are shared in many places. When working with tables, diagrams, and charts, 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 scientific and/or technical information orally and/or in written formats, including various forms of media as well as tables, diagrams, and charts. See the Science-Centered Language Development chapter for strategies on how to build students’ ability to communicate.

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

- In the *Water and Climate Module*, students obtain, evaluate, and communicate information about the properties and distribution of water, and the human impact on water.
- In the *Motion and Matter Module*, students obtain, evaluate, and communicate information about forces involved in rotating tops.
- In the *Structures of Life Module*, students obtain, evaluate, and communicate information about forces involved in rotating tops.
### 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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<td>Ask questions about what would happen if a variable is changed.</td>
<td>Inv 5, Part 3, Step 17: Have a sense-making discussion</td>
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<td>Identify scientific (testable) and non-scientific (non-testable) questions.</td>
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| Ask questions that can be investigated [and predict reasonable outcomes] based on patterns such as cause and effect relationships. | Inv 2, Part 4, Step 1: Discuss making water very cold  
Inv 3, Part 4, Step 2: Focus question: What else affects how fast water evaporates?  
Inv 3, Part 5, Step 4: Investigate the origin of moisture  
Inv 5, Part 1, Step 2: Introduce earth materials |
<p>| Use prior knowledge to describe problems that can be solved.             |                                                                                         |
| Define a simple design problem that can be solved through the development of a new or improved object or tool [an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost]. | Inv 5, Part 3, Step 10: Introduce criterion and criteria |</p>
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<td>Inv 1, Part 2, Step 4: Plan the investigation</td>
<td>Inv 3, Part 1, Step 10: Introduce crustacean</td>
</tr>
<tr>
<td>Inv 1, Part 2, Step 13: Discuss science practices</td>
<td></td>
</tr>
<tr>
<td>Inv 2, Part 1, Step 10: Explore building a variety of systems</td>
<td></td>
</tr>
<tr>
<td>Inv 3, Part 3, Step 2: Focus question: student-created question</td>
<td></td>
</tr>
<tr>
<td>Inv 3, Part 4, Step 12: Review focus questions for Investigation 3</td>
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</tr>
<tr>
<td>Inv 2, Part 4, Step 7: Develop questions for designing an investigation</td>
<td>Inv 1, Part 4, Step 9: Distribute action cards and define problem</td>
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<th>Practices</th>
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<tr>
<td>Identify limitations of models.</td>
<td></td>
</tr>
<tr>
<td>Collaboratively develop and/or revise a model based on evidence that shows the relationships among variables for frequent and regular occurring events.</td>
<td>Inv 2, Part 2, Step 10: Have a sense-making discussion&lt;br&gt;Inv 2, Part 3, Step 14: Read “Water: Hot and Cold”&lt;br&gt;Inv 3, Part 2, Step 5: Have a sense-making discussion on evaporation</td>
</tr>
<tr>
<td>Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution.</td>
<td>Inv 2, Part 2, Step 10: Have a sense-making discussion&lt;br&gt;Inv 2, Part 3, Step 14: Read “Water: Hot and Cold”&lt;br&gt;Inv 3, Part 2, Step 5: Have a sense-making discussion on evaporation</td>
</tr>
<tr>
<td>Develop [and/or use] models to describe [and/or predict] phenomena.</td>
<td>Inv 1, Part 1, Step 13: Answer the focus question&lt;br&gt;Inv 1, Part 4, Step 13: Answer the focus question&lt;br&gt;Inv 2, Part 2, Step 17: Consider orientation of the thermometer&lt;br&gt;Inv 2, Part 3, Step 15: Use a concept definition map strategy&lt;br&gt;Inv 2, Part 4, Step 13: Have a sense-making discussion&lt;br&gt;Inv 3, Part 2, Step 5: Have a sense-making discussion on evaporation&lt;br&gt;Inv 3, Part 5, Step 21: Have a sense-making discussion</td>
</tr>
<tr>
<td>Develop a diagram or simple physical prototype to convey a proposed object, tool, or process.</td>
<td>Inv 2, Part 2, Step 10: Have a sense-making discussion&lt;br&gt;Inv 2, Part 3, Step 14: Read “Water: Hot and Cold”&lt;br&gt;Inv 3, Part 5, Step 7: Introduce the condensation chamber</td>
</tr>
<tr>
<td>Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system.</td>
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<tr>
<td>Motion and Matter Module</td>
<td>Structures of Life Module</td>
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<tr>
<td>Inv 1, Part 1, Step 10: Answer the focus question by drawing a model</td>
<td>Inv 1, Part 4, Step 15: Review the use of physical models</td>
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<tr>
<td>Inv 1, Part 4, Step 6: Introduce making a physical model</td>
<td>Inv 3, Part 3, Step 7: Discuss recording crayfish movements</td>
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<tr>
<td>Inv 2, Part 2, Step 11: Answer the focus question</td>
<td>Inv 1, Part 4, Step 31: Check the “bones”</td>
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<td>Inv 4, Part 3, Step 35: Compare model legs to real legs</td>
<td>Inv 3, Part 2, Step 27: Introduce the simulation</td>
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<td>Inv 3, Part 5, Step 3: Describe the food-chain activity</td>
<td>Inv 3, Part 2, Step 21: Introduce Mr. Bones</td>
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<tr>
<td>Inv 4, Part 3, Step 15: Introduce ball-and-socket joints</td>
<td>Inv 4, Part 3, Step 31: Check the “bones”</td>
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### Science and Engineering Practices—Grade 3

#### Practices

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<th>Practices</th>
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| Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. | Inv 1, Part 2, Step 5: Start the activity  
Inv 1, Part 3, Step 4: Plan the sponge investigation  
Inv 1, Part 4, Step 3: Discuss the activity  
Inv 3, Part 1, Step 7: Collect weather data from a website  
Inv 3, Part 3, Step 3: Set up the tray  
Inv 3, Part 5, Step 4: Investigate the origin of moisture |
| Evaluate appropriate methods and/or tools for collecting data.                                  | Inv 5, Part 1, Step 11: Assess progress: response sheet |
| Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. | Inv 1, Part 8: Start the investigation  
Inv 2, Part 10: Get hot and cold water  
Inv 2, Part 5: Start the hot-water challenge  
Inv 2, Part 2: Focus question: Where should an animal go to stay warm or to stay cool?  
Inv 3, Part 6: Measure the evaporation results |
<p>| Make predictions about what would happen if a variable changes.                                |                                                                                             |
| Test two different models of the same proposed object, tool, or process to determine which better meets criteria for success. |                                                                                             |</p>
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<td>Inv 1, Part 2, Step 4: Plan the investigation</td>
<td>Inv 1, Part 3, Step 4: Design an investigation</td>
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<tr>
<td>Inv 2, Part 1, Step 10: Explore building a variety of systems</td>
<td>Inv 3, Part 3, Step 4: Discuss a plan</td>
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<tr>
<td>Inv 2, Part 3, Step 2: Introduce standard and variable</td>
<td>Inv 3, Part 3, Step 9: Record the Investigation plan</td>
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<td>Inv 2, Part 3, Step 12: Conduct more investigations</td>
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<td>Inv 3, Part 3, Step 4: Discuss recording data</td>
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<thead>
<tr>
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<tr>
<td>Inv 2, Part 2, Step 4: Plan the investigation</td>
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<td>Inv 2, Part 2, Step 5: Introduce magnetic-force activities</td>
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<td>Inv 2, Part 2, Step 5: Introduce the park-under-the-ramp challenge</td>
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<td><strong>Inv 2, Part 2, Step 9: Record and share results</strong></td>
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<td>Inv 3, Part 1, Step 3: Distribute materials and begin work</td>
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<td>Inv 4, Part 1, Step 6: Make plans</td>
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<tr>
<td>Inv 4, Part 2, Step 6: Start the investigation</td>
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</tr>
<tr>
<td>Inv 3, Part 3, Step 5: Let the Investigation begin</td>
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<td>Inv 1, Part 2, Step 17: Record changes over 6 days</td>
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<td>Inv 1, Part 3, Step 11: Weigh the soaked lima bean seeds</td>
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<td>Inv 2, Part 1, Step 12: Place the seedlings in the holder</td>
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<td>Inv 3, Part 2, Step 29: Distribute the notebook sheet</td>
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<td>Inv 4, Part 2, Step 5: Observe pellets</td>
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<td>Inv 4, Part 3, Step 7: Begin the tasks</td>
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<td>Inv 1, Part 2, Step 13: Discuss science practices</td>
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<td>Inv 2, Part 3, Step 11: Discuss making predictions</td>
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*Science and Engineering Practices—Grade 3*
### Science and Engineering Practices—Grade 3

#### Practices

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<th>Analyzing and interpreting data</th>
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| Represent data in tables and/or various graphical displays (bar graphs, pictographs, [and/or pie charts]) to reveal patterns that indicate relationships. | Inv 1, Part 2, Step 10: Discuss size results  
Inv 2, Part 5, Step 5: Start the activity  
Inv 3, Part 3, Step 6: Measure the evaporation results.  
Inv 3, Part 3, Step 11: Read “Surface: Area Experiment”  
Inv 3, Part 4, Step 13: Compare locations  
Inv 4, Part 1, Step 5: Discuss ways to organize the data |
| Analyze and interpret data to make sense of phenomena, using logical reasoning, [mathematics, and/or computation]. | Inv 1, Part 2, Step 22: Share notebook entries  
Inv 2, Part 4, Step 13: Have a sense-making discussion  
Inv 3, Part 1, Step 14: Look for patterns after 7 days  
Inv 3, Part 3, Step 7: Have a sense-making discussion  
Inv 4, Part 1, Step 6: Discuss ways to organize the data |
| Compare and contrast data collected by different groups in order to discuss similarities and differences in their findings. | Inv 1, Part 3, Step 16: Share notebook entries  
Inv 3, Part 1, Step 12: Make comparisons |
| Analyze data to refine a problem statement or the design of a proposed object, tool, or process. | Inv 2, Part 1, Step 12: Have a sense-making discussion |
| Use data to evaluate and refine design solutions. | Inv 2, Part 1, Step 12: Have a sense-making discussion  
Inv 5, Part 3, Step 18: Improve designs |
| Decide if qualitative or quantitative data are best to determine whether a proposed object or tool meets criteria for success. |  |
| Organize simple data sets to reveal patterns that suggest relationships. | Inv 3, Part 3, Step 6: Measure the evaporation results. |
| Describe, measure, estimate, and/or graph quantities (e.g., area, volume, weight, time) to address scientific and engineering questions and problems. | Inv 1, Part 3, Step 6: Answer the focus question  
Inv 1, Part 3, Step 1: Introduce the milliliters/gram relationship  
Inv 3, Part 3, Step 6: Measure the evaporation results |
<p>| Create and/or use graphs and/or charts generated from simple algorithms to compare alternative solutions to an engineering problem. |  |</p>
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<tbody>
<tr>
<td>Inv 4, Part 2, Step 7: Record group results on the board</td>
<td>Inv 1, Part 1, Step 6: Count and graph the seeds in the pods</td>
</tr>
<tr>
<td>Inv 1, Part 2, Step 5: Conduct the Investigation in pairs</td>
<td>Inv 2, Part 1, Step 4: Compare the properties of germinated seeds</td>
</tr>
<tr>
<td>Inv 1, Part 2, Step 13: Discuss science practices</td>
<td>Inv 3, Part 4, Step 13: Make Venn diagrams of structures</td>
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<tr>
<td>Inv 2, Part 3, Step 11: Discuss making predictions</td>
<td>Inv 4, Part 4, Step 13: Create a thumbprints bar graph</td>
</tr>
<tr>
<td>Inv 3, Part 3, Step 5: Let the Investigation begin</td>
<td>Inv 1, Part 1, Step 6: Compare one structure</td>
</tr>
<tr>
<td>Inv 4, Part 1, Step 9: Discuss findings</td>
<td>Inv 2, Part 2, Step 9: Introduce plant life cycle</td>
</tr>
<tr>
<td>Inv 4, Part 2, Step 9: Analyze results</td>
<td>Inv 3, Part 2, Step 11: Discuss making predictions</td>
</tr>
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<td>Inv 3, Part 3, Step 12: Discuss the data in groups</td>
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<td>Inv 3, Part 5, Step 10: Count survivors</td>
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<td>Inv 4, Part 1, Step 24: Monitor the work on the puzzles</td>
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<td>Inv 4, Part 2, Steps 9-10: Compare bones</td>
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<tr>
<td><strong>Inv 4, Part 2, Step 11: Have a sense-making discussion</strong></td>
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<tr>
<td></td>
<td><strong>Inv 4, Part 2, Step 11: Have a sense-making discussion</strong></td>
</tr>
<tr>
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<td>Inv 4, Part 3, Step 9: Discuss students’ findings</td>
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<tr>
<td>Inv 1, Part 2, Step 4: Plan the investigation</td>
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<tr>
<td>Inv 3, Part 2, Step 9: Design and test new carts</td>
<td>Inv 3, Part 2, Step 25: Discuss results</td>
</tr>
<tr>
<td>Inv 3, Part 2, Step 9: Design and test new carts</td>
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<tr>
<td>Inv 4, Part 3, Step 9: Determine winners</td>
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</tr>
<tr>
<td>Practices</td>
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<tr>
<td>--------------------------------------------------------------------------</td>
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</tbody>
</table>
| Construct an explanation of observed relationships (e.g., the distribution of plants in the back yard). | Inv 1, Part 1, Step 13: Have a sense-making discussion  
Inv 2, Part 2, Step 15: Constructing explanations  
Inv 3, Part 4, Step 13: Compare locations  
Inv 3, Part 4, Step 18: Assess progress: response sheet  
Inv 4, Part 2, Step 5: Determine climate regions |
| Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation (or design a solution to a problem.) | Inv 1, Part 2, Step 13: Have a sense-making discussion  
Inv 1, Part 2, Step 15: Answer the focus question  
Inv 1, Part 3, Step 6: Answer the focus question  
Inv 1, Part 4, Step 17: Review focus question  
Inv 2, Part 3, Steps 7,9: Discuss observations of water  
Inv 2, Part 3, Step 15: Use a concept definition map strategy  
Inv 2, Part 4, Step 19: Assess progress: response sheet  
Inv 2, Part 5, Step 11: Review focus questions for Investigation 2  
Inv 3, Part 3, Step 7: Have a sense-making discussion  
Inv 3, Part 3, Step 12: Discuss the reading  
Inv 3, Part 4, Step 17: Answer the focus question  
Inv 3, Part 5, Step 15: Answer the focus question  
Inv 3, Part 5, Step 24: Review focus questions for Investigation 3  
Inv 4, Part 1, Step 8: Share graphical displays  
Inv 4, Part 1, Step 12: Answer the focus question  
Inv 4, Part 2, Step 15: Answer the focus question  
Inv 4, Part 3, Step 18: Review focus questions for Investigation 4  
Inv 5, Part 1, Step 8: Have a sense-making discussion  
Inv 5, Part 3, Step 22: Answer the focus question |
| Identify the evidence that supports particular points in an explanation.   |                                                                                         |
| Apply scientific ideas to solve design problems.                        | Inv 5, Part 3, Step 16: Record results                                                  |
| Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution. | Inv 2, Part 5, Step 9: Answer the focus question  
Inv 4, Part 3, Step 12: Discuss the reading  
Inv 5, Part 3, Step 16: Record results |
### Motion and Matter Module

- Inv 1, Part 1, Step 12: Summarize the forces of magnetism and gravity
- Inv 1, Part 3, Step 16: Review focus questions for Investigation 1
- Inv 2, Part 2, Step 11: Discuss the addition of weight
- Inv 2, Part 4, Step 19: Review focus questions for Investigation 2
- Inv 3, Part 1, Step 9: Answer the focus question
- Inv 3, Part 2, Step 14: Answer the focus question
- Inv 3, Part 3, Step 12: Answer the focus question
- Inv 3, Part 4, Step 12: Review focus questions for Investigation 3

**Inv 4, Part 1, Step 9: Have a sense-making discussion**
- Inv 4, Part 1, Step 14: Answer the focus question
- Inv 4, Part 1, Step 16: Discuss the reading
- Inv 4, Part 3, Step 16: Review focus questions for Investigation 4

- Inv 2, Part 4, Step 7: Develop questions for designing an investigation
- Inv 2, Part 5, Step 9: Answer the focus question

### Structures of Life Module

- Inv 1, Part 3, Step 17: Answer the focus question
- Inv 1, Part 4, Step 17: Reflect on seed dispersal
- Inv 1, Part 4, Step 20: Discuss the reading
- Inv 1, Part 4, Step 22: Review focus questions
- Inv 2, Part 1, Step 8: Answer the focus question
- Inv 2, Part 2, Step 9: Introduce plant life cycle
- Inv 2, Part 2, Step 15: Review organism
- Inv 2, Part 3, Step 11: Introduce or review inheritance
- Inv 2, Part 3, Step 18: Review focus questions
- Inv 3, Part 1, Step 22: Discuss the reading
- Inv 3, Part 2, Step 19: Discuss the reading
- Inv 3, Part 2, Step 38: Share notebook entries
- Inv 3, Part 3, Step 14: Hold a class discussion
- Inv 3, Part 4, Step 15: Assess progress: response sheet
- Inv 3, Part 5, Step 16: Answer the focus question
- Inv 3, Part 5, Step 19: Discuss the reading
- Inv 3, Part 5, Step 21: Review focus questions
- Inv 4, Part 1, Step 33: Share notebook entries
- Inv 4, Part 2, Step 14: Answer the focus question
- Inv 4, Part 2, Step 22: Read “Fossils”
- Inv 4, Part 4, Step 20: Discuss the reading
- Inv 4, Part 4, Step 22: Review focus questions
- Inv 5, Part 3, Step 16: Record results
- Inv 5, Part 3, Step 16: Record results
- Inv 5, Part 3, Step 16: Record results
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<td>Compare and refine arguments based on an evaluation of the evidence presented.</td>
<td>Inv 3, Part 5, Step 21: Have a sense-making discussion</td>
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<tr>
<td>Distinguish among facts, reasoned judgment based on research findings, and speculation in an explanation.</td>
<td>Inv 1, Part 3, Step 14: Discuss the reading</td>
</tr>
<tr>
<td>Respectfully provide and receive critiques from peers about a proposed procedure, explanation, or model by citing relevant evidence and posing specific questions.</td>
<td>Inv 2, Part 1, Step 21: Share notebook entries</td>
</tr>
<tr>
<td>Construct and/or support an argument with evidence, data, and/or a model.</td>
<td>Inv 3, Part 3, Step 7: Have a sense-making discussion</td>
</tr>
<tr>
<td>Use data to evaluate claims about cause and effect.</td>
<td>Inv 3, Part 4, Step 21: Engage in argumentation</td>
</tr>
<tr>
<td>Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.</td>
<td>Inv 5, Part 2, Step 19: Discuss the SODIS process</td>
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<tr>
<td>Inv 4, Part 2, Step 20: Share notebook entries</td>
<td>Inv 1, Part 3, Step 21: Engage in argument from evidence</td>
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<td>Inv 3, Part 3, Step 23: Engage in argument from evidence</td>
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<td>Inv 3, Part 4, Step 22: Share notebook entries</td>
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<td>Inv 4, Part 2, Step 23: Read “Skeletons on the Outside”</td>
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<td>Inv 1, Part 2, Step 2: Present the challenge</td>
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<td>Inv 1, Part 3, Step 21: Engage in argument from evidence</td>
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<td>Inv 2, Part 2, Step 5: Engage in argument from evidence</td>
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<td>Inv 3, Part 3, Step 14: Hold a class discussion</td>
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<td>Inv 4, Part 2, Step 23: Read “Skeletons on the Outside”</td>
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<td>Practices</td>
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<tr>
<td>Read and comprehend grade-appropriate complex texts and/or other reliable media to summarize and obtain scientific and technical ideas and describe how they are supported by evidence.</td>
<td>Inv 1, Part 1, Step 15: Read “A Report from the Blue Planet”</td>
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<td>Inv 4, Part 3, Step 11: Read “Wetlands for Flood Control”</td>
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<td>Inv 5, Part 2, Step 17: Discuss the reading</td>
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<tr>
<td>Compare and/or combine across complex texts and/or other reliable media to support the engagement in other scientific and/or engineering practices.</td>
<td></td>
</tr>
<tr>
<td>Obtain and combine information from books and/or other reliable media to explain phenomena (or solutions to a design problem).</td>
<td>Inv 1, Part 2, Steps 16-20: Read FOSS Science Resources articles, view video, use multimedia</td>
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<td>Inv 2, Part 4, Step 22: Discuss the reading</td>
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<td>Inv 3, Part 1, Step 11: Montior data collection</td>
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<td>Inv 4, Part 2, Step 15: Answer the focus question</td>
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<td>Inv 4, Part 3, Step 10: Have a sense-making discussion</td>
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<td>Inv 4, Part 3, Step 12: Discuss the reading</td>
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<td>Inv 4, Part 3, Step 18: Review focus questions for Investigation 4</td>
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<td>Inv 5, Part 1, Step 13: Discuss the reading</td>
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<tr>
<td>Communicate scientific and/or technical information orally and/or in written formats, including various forms of media and may include tables, diagrams, and charts.</td>
<td>Inv 3, Part 1, Step 18: Read “Studying Weather”</td>
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<td>Inv 1, Part 3, Step 9: Read “Change of Motion”</td>
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<td>Inv 2, Part 1, Step 16: Discuss the reading</td>
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<td>Inv 2, Part 2, Step 18: Discuss the reading</td>
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<td>Inv 3, Part 1, Step 21: Use a concept grid</td>
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<td>Inv 4, Part 1, Step 31: Discuss the reading</td>
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<td>Inv 4, Part 2, Step 25: Discuss the reading</td>
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<td>Inv 2, Part 2, Step 17: Discuss rolling cups</td>
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<td>Inv 2, Part 4, Step 17: Discuss the reading</td>
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<td>Inv 3, Part 2, Step 15: Find specific animal adaptations</td>
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<td>Inv 2, Part 3, Step 12: Conduct more investigations</td>
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<td>Inv 3, Part 4, Step 6: Facilitate engineering conferences</td>
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