Gathering evidence of three-dimensional learning
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</table>
Welcome to Measured Progress STEM Gauge

As a teacher you know that children naturally connect to the world around them. They ask questions and explore with all their senses—to the point of happily tasting mud!

This curiosity of a young child represents the essence of the scientific endeavor. Actively seeking to understand, young students construct knowledge as they investigate and make sense of the natural and designed world. They build things, knock them down, and try again.

**STEM Gauge** is a formative assessment resource that supports classroom instruction in the transition to the Next Generation Science Standards (NGSS). **STEM Gauge** provides students with opportunities to demonstrate understanding of the 3 dimensions of performance expectations as instruction occurs.

**STEM Gauge** gives you tools to help you gain insight to students’ growing understanding.

This guide is written specifically for you, a classroom teacher for students in kindergarten through grade 5. It supports your transition to the NGSS and will help you get the most out of the assessment items, tools, and resources included in each **STEM Gauge** topic-based item set.

Whether you are just beginning to learn about the NGSS or have already implemented NGSS-based curriculum resources in your classroom, **STEM Gauge** can help.

How do you know where students are in their learning progressions toward mastery of the NGSS PEs?

Use **STEM Gauge** resources to find out!
Next Generation Science Standards Overview

The Next Generation Science Standards (NGSS) represent an innovative approach to science education that supports a child’s learning from kindergarten through high school. Built on a solid foundation, the NGSS are innovative because they integrate:

- Three-dimensional (3-D) learning
- Explanations of phenomena and design solutions
- Engineering design and the nature of science
- Coherent learning progressions from kindergarten through high school
- Connections to English language arts (ELA) and mathematics

Three dimensions

The standards are performance expectations (PEs) that identify what students are expected to master by the end of instruction. The PEs blend together three equally important learning dimensions.

- **Disciplinary core ideas (DCIs)** represent what scientists and engineers know, or the academic core content.
- **Science and engineering practices (SEPs)** represent what scientists and engineers do, or the behaviors scientists and engineers use to investigate the natural world and to design solutions to problems.
- **Crosscutting concepts (CCCs)** represent how scientists and engineers think as they look for common framing concepts that span all domains of science.

The DCIs, SEPs, and CCCs are shown in the illustration on the right.

### Science and engineering Practices

<table>
<thead>
<tr>
<th>Practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asking questions (for science) and defining problems (for engineering)</td>
</tr>
<tr>
<td>Developing and using models</td>
</tr>
<tr>
<td>Planning and carrying out investigations</td>
</tr>
<tr>
<td>Analyzing and interpreting data</td>
</tr>
<tr>
<td>Using mathematics and computational thinking</td>
</tr>
<tr>
<td>Constructing explanations (for science) and designing solutions (for engineering)</td>
</tr>
<tr>
<td>Engaging in argument from evidence</td>
</tr>
<tr>
<td>Obtaining, evaluating, and communicating information</td>
</tr>
</tbody>
</table>

### Disciplinary Core Ideas

- Physical Sciences
- Life Sciences
- Earth and Space Sciences
- Engineering Design

### Crosscutting Concepts

- Patterns
- Cause and effect
- Scale, proportion, and quantity
- Systems and system models
- Energy and matter
- Structure and function
- Stability and change

Print this poster >>

STEM Gauge Elementary Teacher’s Guide
Crosscutting Concepts: A Conceptual Framework

The crosscutting concepts (CCC) provide students with a conceptual framework to construct knowledge and understanding across the different science and engineering domains. The NGSS were built upon other documents, including A Framework for K–12 Science Education. This work first identified the three dimensions of the new science standards and emphasized that each dimension, including the crosscutting concepts, was equally important.

As an elementary school teacher, you are in an ideal position to anchor the crosscutting concepts early in your students’ science education. Using these common terms early and often will help students see that the same concept can be applied across different contexts. The table below shows the sequence in which the crosscutting concepts are introduced in the PEs, by grade level.

Even though the performance expectations in each elementary grade emphasize particular crosscutting concepts, you can and should use all of the CCCs in your classroom.

STEM Gauge Elementary includes three kinds of supports to help you highlight and reinforce the CCCs in your classroom:

- Icon cards that help students recognize the seven CCCs.
- Formative Support Tools help engage students and support teachers in the formative assessment process.
- Instructional Strategies that support student learning and provide evidence of student progress.

“Although crosscutting concepts are fundamental to an understanding of science and engineering, students have often been expected to build such knowledge without any explicit instructional support. Hence the purpose of highlighting them as Dimension 2 of the framework is to elevate their role in the development of standards, curricula, instruction, and assessments. These concepts should become common and familiar touchstones across the disciplines and grade levels. Explicit reference to the concepts, as well as their emergence in multiple disciplinary contexts, can help students develop a cumulative, coherent, and usable understanding of science and engineering.”

Crosscutting Concepts included at each grade level

<table>
<thead>
<tr>
<th>Crosscutting Concepts</th>
<th>K</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patterns</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Cause and Effect</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Systems and System Models</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Energy and Matter</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Scale, Proportion, and Quantity</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
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</tr>
<tr>
<td>Structure and Function</td>
<td>✓</td>
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<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stability and Change</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

“Although crosscutting concepts are fundamental to an understanding of science and engineering, students have often been expected to build such knowledge without any explicit instructional support. Hence the purpose of highlighting them as Dimension 2 of the framework is to elevate their role in the development of standards, curricula, instruction, and assessments. These concepts should become common and familiar touchstones across the disciplines and grade levels. Explicit reference to the concepts, as well as their emergence in multiple disciplinary contexts, can help students develop a cumulative, coherent, and usable understanding of science and engineering.”
Science and Engineering Practices

Engaging in the Science and Engineering Practices (SEP) is essential for students to understand the relevancy of the content and skills they are learning. One way to start your NGSS transition is to consider ways to integrate or blend the SEPs with the Crosscutting Concepts (CCC) and Disciplinary Core Ideas (DCI). Rather than presenting content and concepts in isolation, this approach integrates scientific knowledge with practice—mirroring the way real scientists and engineers work.

A Framework for K–12 Science Education states, “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.”

STEM Gauge

Elementary includes three kinds of supports to help you highlight and reinforce the SEPs in your classroom:

- **Icon cards** that help students recognize the seven CCCs.
- **Formative Support Tools** help engage students and support teachers in the formative assessment process.
- **Instructional Strategies** that support student learning and provide evidence of student progress.

Using common terms early and often will help students recognize how the practices are connected to the crosscutting concepts and disciplinary core ideas. **STEM Gauge** provides opportunities for your students to learn disciplinary core ideas in the context of science and engineering practices and crosscutting concepts. The items and activities in **STEM Gauge** are written to the PE and explicitly include the practice addressed in that PE. Some items address multiple practices. This is intentional and supports the recommendation to integrate multiple practices. For example, the practice of “asking questions” may lead to the practice of “modeling” or “planning and carrying out an investigation,” which in turn may lead to “analyzing and interpreting data.”

Learning Progressions for the Science and Engineering Practices for grades K–12 are located [here](#).
**STEM Gauge** includes:

- 15 NGSS-designed topic-based item sets of assessment items and activities that come in print-ready PDF format and in QTI format for computer-based use
- This Teacher’s Guide with strategies for using the items to gather evidence of students’ understanding
- Formative Support Tools that help you integrate the NGSS into classroom instruction and assessment
- A Scoring Guide for each topic-based item set that includes answer keys, distractor rationales, rubrics, and scoring notes
- English Language Arts (ELA) Connection topic sets containing 6–10 ELA items as supplements to some of the STEM Gauge topic sets that incorporate a passage
- Developmentally appropriate performance-based activities for kindergarten and grade 1 that can be used with a whole class, a small group, or individuals
- Item-level suggestions for connections to Common Core State Standards to reinforce an integrated approach to learning

**STEM Gauge** can be an integral part of your formative assessment practices:

“...a process teachers and students use during instruction that provides feedback to adjust ongoing teaching moves and learning tactics.”  

---

**Structure and Properties of Matter**

**PERFORMANCE EXPECTATION**

SEP.3-5.2.d Developing and Using Models

**ID:** 424030

José claims that air is made of tiny particles of matter. He has a basketball and a pump, as shown.

Use the basketball and pump to provide evidence to support your claim.

**DCI:** 5-PS1-1: Structure and Properties

**Grade 5 NGSS**

Develop a model to describe that matter is made of particles too small to be seen.

**Item Count**

ER (extended-response—3 points) 3 3 4 3

**Mobile:**

A wind sock is a cone made of cloth. Wind can move through it because it is open at both ends. Wind socks are mounted on tall posts at airports to show pilots how fast the wind is moving. The diagram shows how a wind sock appears at various wind speeds.

12–19 km/hr

6–11 km/hr

1–5 km/hr

---

**Name:**

**Student Learning Target:**

- I’m still wondering…
- Stop! I am just beginning this.
- Wait! I am still working on this.
- Go! I can do this! I am ready to go on.

---

For more information about the NGSS, visit measuredprogress.org

...a process teachers and students use during instruction that provides feedback to adjust ongoing teaching moves and learning tactics.”
STEM Gauge Elementary Overview

**STEM Gauge** Elementary contains 15 topic-based item sets, each with 20–25 assessment items. For grades 3–5, each set is based on an NGSS topic, and its items are aligned to the performance expectations (PES) for the topic. For kindergarten—grade 2, one set of items addresses the NGSS topics in a single domain. The sets span the content domains of Life Science, Earth and Space Science, and Physical Science, as shown in the chart below.

**ELA Connection**
For 10 of the elementary item sets, the STEM Gauge ELA Connection provides additional ELA items that go with reading passages within the STEM Gauge topic-based items sets. The ELA items are aligned to the CCSS. These passages help reinforce the interdisciplinary nature of instruction for students at this age.

**Support for Early Grades**
The 3 domain-level items sets for K–2 include developmentally appropriate performance-based K–1 activities. These activities are designed for whole-class, small-group, and individual participation. Resources are provided to help teachers collect evidence of understanding.

**Designed for flexibility**
With the purchase of STEM Gauge Elementary, educators have access to all 15 topic-based item sets, which each contain 20–25 assessment items aligned to the NGSS. This collection provides flexibility and choice for either a discipline-based or integrated instruction model. STEM Gauge works with all kit- or textbook-based curricula. Full access also gives you the potential for differentiated instruction; you can use items that are designed to similar topics from an earlier or later grade, depending on your students’ interests and learning needs.

### 15 STEM Gauge Elementary Topic-Based Item Sets in the K–5 Grade Span

<table>
<thead>
<tr>
<th>Grade Span or Grade</th>
<th>Life Science</th>
<th>Earth and Space Science</th>
<th>Physical Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>K–2</td>
<td>Interdependent Relationships in Ecosystems (K)</td>
<td>Weather and Climate (K)</td>
<td>Forces and Interactions: Pushes and Pulls (K)</td>
</tr>
<tr>
<td></td>
<td>Structure, Function, and Information Processing (1)</td>
<td>Space Systems: Patterns and Cycles (1)</td>
<td>Waves: Light and Sound (1)</td>
</tr>
<tr>
<td></td>
<td>Interdependent Relationships in Ecosystems (2)</td>
<td>Earth’s Systems: Processes that Shape the Earth (2)</td>
<td>Structure and Properties of Matter (2)</td>
</tr>
<tr>
<td>3</td>
<td>Inheritance and Variation of Traits: Life Cycles and Traits</td>
<td>Weather and Climate</td>
<td>Forc and Interactions</td>
</tr>
<tr>
<td></td>
<td>Interdependent Relationships in Ecosystems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Structure, Function and Information Processing</td>
<td>Earth’s Systems: Processes that Shape the Earth</td>
<td>Waves: Waves and Information</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Energy</td>
</tr>
<tr>
<td>5</td>
<td>Matter and Energy in Organisms and Ecosystems</td>
<td>Earth’s Systems</td>
<td>Structure and Properties of Matter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Space Systems: Stars and the Solar System</td>
<td></td>
</tr>
</tbody>
</table>

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**STEM Gauge Elementary Teacher’s Guide**
STEM Gauge Elementary Overview

STEM Gauge uses assessment items and activities to reveal students’ understanding—to you and to the students themselves—as they move along a continuum of learning toward mastery of the NGSS PEs.

Support for formative assessment
Each STEM Gauge topic-based item set can be used in a variety of ways for formative assessment. You can strategically integrate items into instruction as ongoing checkpoints to inform instructional next steps.

The STEM Gauge items are not intended to determine student mastery of NGSS PEs on end-of-instruction tests. Also, the 20–25 items within a single topic set are not designed to be used together in a single assessment.

Evidence statements
Content specialists used the NGSS Evidence Statements to guide their development of the items and activities in each STEM Gauge topic-based item set. These Evidence Statements identify specific things that students should be able to do as they move toward mastery of the PEs. Each STEM Gauge question or activity is intended to be embedded in classroom instruction to provide evidence of student learning toward a target PE.

PE mastery happens over time
No single STEM Gauge question can address the full breadth of a PE. However, this Teacher’s Guide provides instructional strategies and formative support tools that support your ability to assess the full breadth of the PEs over time, during instruction.

STEM Gauge items provide evidence of learning during instruction so that you can modify your instruction in real time to address weaknesses in understanding and/or misconceptions among your students.

STEM Gauge supports 3-D learning in your classroom, outside in nature, for individual students, and with student groups.
Items and Item Types

The 15 STEM Gauge Elementary topic-based item sets accomplish two things: they elicit evidence of understanding of the three dimensions and they gauge students’ progress toward meeting PEs. The grades 3–5 item sets each include three different item types: multiple-choice, constructed-response, and extended-response. The K–2 item sets include a fourth item type, activities, for students in kindergarten and grade 1.

The distribution of item types within an item set varies depending on the PEs. Some PEs are best assessed with constructed- or extended-response items, so few multiple-choice items are used in those particular item sets. Each topic-based item set contains 20–25 items.

See examples of each item type by clicking the headings on the right >>

Multiple-choice (MC): 1-point items >>
MC items include an item stem and answer options. The incorrect answer options, or distractors, are often based on typical misconceptions. The Scoring Guide for each STEM Gauge MC item includes distractor rationales that identify the correct answer and help explain why each other option is incorrect. An analysis of students’ answer choices provides evidence of the students’ current level of understanding of key concepts and skills.

Constructed-response (CR): 2-point items >>
A CR item presents an open-ended prompt that gives students the opportunity to write answers that demonstrate application of scientific practices—including scientific explanations. These items also allow students to practice higher-order thinking skills such as analyzing and synthesizing. Different CR items call for varying response lengths—from brief sentences to explanations with drawings.

Extended-response (ER): 3-point items >>
ER items present open-ended prompts that require more writing than CR items. ER items actively engage students in constructing and organizing their knowledge by asking students to explain, elaborate, and question their own thinking.

Activities: 2-point items >>
Performance-based activities are provided for students in kindergarten and grade 1. At these two grade levels, which include both readers and nonreaders, these classroom activities engage students in scientific behaviors that demonstrate their understanding.
Space Systems: Stars and the Solar System

Students who demonstrate understanding can:

5-PS2-1 Support an argument that the gravitational force exerted by Earth on objects is directed down.

Vanessa makes a scientifically correct claim about gravity affecting all objects on Earth. She wants evidence to support her claim.

Vanessa uses the Internet to communicate with students around the world. She asks these students to use a basketball to investigate a question.

Which question will most likely provide the strongest evidence to support Vanessa’s claim?

A How far does a basketball roll along the ground after being kicked?
B How high does a basketball bounce after being thrown onto the ground?
C What happens when you let some air out of a basketball and then bounce it?
D What happens when you hold a basketball above the ground and then release it?
Inheritance and Variation of Traits

Students who demonstrate understanding can:

3-LS3-1 Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms.

Two parent rabbits are shown.

The mother has straight ears and short, black-and-white fur. The father has long ears that hang down and long, white fur. The traits of their four babies are listed in this chart.

<table>
<thead>
<tr>
<th>Baby Rabbit</th>
<th>Ear Type</th>
<th>Fur Color</th>
<th>Fur Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Straight</td>
<td>Black and white</td>
<td>Long</td>
</tr>
<tr>
<td>2</td>
<td>Hangs down</td>
<td>Black</td>
<td>Long</td>
</tr>
<tr>
<td>3</td>
<td>Straight</td>
<td>Black</td>
<td>Long</td>
</tr>
<tr>
<td>4</td>
<td>Hangs down</td>
<td>Black and white</td>
<td>Long</td>
</tr>
</tbody>
</table>

a. Describe how information in the chart shows that ear type is an inherited trait.

b. Describe how the pattern of traits in the chart shows that a baby rabbit may look different than both parents.
A team of students designed and built an airplane to meet the following criteria (goals):

- fly for at least 60 seconds
- change stored energy into motion energy

The airplane is made of balsa wood (a light wood), a plastic propeller, and a rubber band, as shown.

To test the airplane, the team turns the propeller 10 times to twist the rubber band before releasing the airplane. When the rubber band untwists, the propeller spins and the airplane flies. The team records the number of seconds that the airplane flies. The team does four trials of the same test. The results are shown in the table.

<table>
<thead>
<tr>
<th>Trial</th>
<th>Time Flying (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>60</td>
</tr>
<tr>
<td>2</td>
<td>65</td>
</tr>
<tr>
<td>3</td>
<td>62</td>
</tr>
<tr>
<td>4</td>
<td>61</td>
</tr>
</tbody>
</table>

a. Explain whether the airplane meets the design criteria (goals). Explain your thinking.

b. Describe one way the team could change the design to make the airplane fly longer. Explain your thinking.
Activities

NGSS alignment >>

Item information>>

Scoring information >>

CCSS connections>>

Suggested formative tool >>

Formative Support Tools>>

NGSS ALIGNMENT
PERFORMANCE EXPECTATION: 1-LS1-1: Use materials to design a solution to a human problem by mimicking how plants and/or animals use external parts to help them survive, grow, and meet their needs.

SEP: SEPK-2.6b Constructing Explanations and Designing Solutions
CC: 1.LS1.A.1 Structure and Function

DOK: 3
ID: 499071

Value: 2 Points

Activity

<table>
<thead>
<tr>
<th>Background Information</th>
<th>Materials</th>
</tr>
</thead>
</table>
| Students will recognize the role of an animal’s protective covering and mimic that information to design a solution for a human problem. This activity has whole-group, small-group, and individual components. This activity should go over multiple days (e.g., one day for discussion, one day for design and creation, and one day for presentations). | • Chart paper  
• Pictures of animals (Turtle, Polar bear, Bird, Fish, Duck, Hermit crab, Beetle)  
• Craft materials, such as pipe cleaners, construction paper, cotton balls, craft sticks, aluminum foil, plastic wrap  
• Toilet paper tubes  
• Glue  
• Tape  
• Stapler  
• Writing utensils: pencils, crayons, and/or markers  
• Science journal  
• Rubric (included)  
• Observation Checklist (included)  
• Student Design Worksheet (included) |

Estimated Time

60–75 minutes total

Teacher Script

People (humans) are always looking for ways to keep themselves safe. Some animals have body parts that keep them safe in certain ways.

How can we use what we see about animals to help us make an object that keeps parts of our bodies safe?

Lead a whole-group discussion that introduces the following animals and the body parts that protect them. If needed, use available classroom resources to show pictures of the animals. Write each of the following on a piece of chart paper.

• Turtle—Shell
• Pronghorn—Quills
• Tiger—Sharp claws
• Bees—Stingers
• Lobster—Pincers
• Fish—Scales
• Shark—Sharp teeth
• Hermit crab—Seashell

How does each of these animals use its body parts for protection?

Solicit input from the students for other animals and add them to the chart.

Today, we will make an object to keep a part of your body safe. This object can be based on one of the examples on our chart or you can come up with your own idea, but it must keep a part of your body safe.

Directions may need to be broken down into one- or two-step processes and repeated often.

Student Response

(Possible responses include:)

We can copy what we see in animals and make something that protects us the same way.

How can animals use their body parts to help keep parts of their bodies safe?

Possible Student Response

A polar bear’s fur is very thick. How does thick fur help to keep the polar bear safe?

Polar bear fur also looks white. How can the color of the fur help the polar bear live?

A fish has scales that overlap each other, like this. Use hands resting one on top of the other to show how the scales overlap.

What part of the fish do the scales help to keep safe?

Fish scales are also smooth. How can smooth scales help the fish to live?

Continue the discussion with the four remaining animals. Have students tell what makes the animal part good for helping to keep the animal safe. Continue to encourage students to think about both the structure and the function of the different animals’ parts.

Distribute the Student Design Worksheets to the students. This worksheet is called a Student Design Worksheet. To design something means to plan how you will make it. This worksheet will help you to design, or plan how you will make, an object to keep a part of your body safe.

Think about a part of your body that you need to keep safe. Write or draw this body part in the top space of your worksheet.

How does each of these animals use its body parts for protection?

Student responses will vary, based on the chosen animal and body part.

Notes:

DOK: 3
ID: 499071

STEM Gauge  Elementary Teacher’s Guide

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Two-step processes and repeated often.

Your body safe.

Animal and body part.

Animal and body part.

Animal and body part.

Animal and body part.

Animal and body part.

Animal and body part.

Animal and body part.

Animal and body part.

Animal and body part.

Animal and body part.

Animal and body part.
Students use their content knowledge about waves (DCI) as they describe the pattern of motion (CCC and DCI) and then draw a model (SEP) to show how the pattern changes (CCC) if the amplitude of the wave increases (DCI).

Lee is watching a video of a person on a float in the ocean. This diagram shows the person’s pattern of motion caused by an ocean wave.

a. Describe the person’s pattern of motion caused by an ocean wave.
b. Draw a model to show how the person’s pattern of motion changes when the wave has a greater amplitude.

*Note: Due to the complexity of some of the PEs, some of the assessment items may not address all three dimensions.
Structure and Properties of Matter

Grade 5 NGSS† Performance Expectations

<table>
<thead>
<tr>
<th>PE</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-PS1-1</td>
<td>Develop a model to describe that matter is made of particles too small to be seen.</td>
</tr>
<tr>
<td>5-PS1-2</td>
<td>Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.</td>
</tr>
<tr>
<td>5-PS1-3</td>
<td>Make observations and measurements to identify materials based on their properties.</td>
</tr>
<tr>
<td>5-PS1-4</td>
<td>Conduct an investigation to determine whether the mixing of two or more substances results in new substances.</td>
</tr>
</tbody>
</table>

†NGSS is a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the Next Generation Science Standards were involved in the production of this product, and do not endorse it.

Item Count

<table>
<thead>
<tr>
<th>Item Type</th>
<th>5-PS1-1</th>
<th>5-PS1-2</th>
<th>5-PS1-3</th>
<th>5-PS1-4</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>ER (extended-response—3 points)</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>13</td>
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Student Learning Targets

- **5-PS1-1**: I can make a model to support the claim that matter is made of particles that are too small to be seen. I can use a model to support the claim that matter is made of particles that are too small to be seen.
- **5-PS1-2**: I can measure and graph different amounts of matter to provide evidence that the total weight of matter is conserved no matter what type of change occurs during heating, cooling, or mixing materials.
- **5-PS1-3**: I can use observations of properties to identify materials. I can use measurements of properties to identify materials.
- **5-PS1-4**: I can investigate to find out if mixing two or more substances results in new substances.
As outlined in the Performance Expectations (PE) of the NGSS, the three dimensions are the disciplinary core ideas (DCI), science and engineering practices (SEP), and crosscutting concepts (CCC). Note that due to the complexity of the PEs, individual assessment items may not address all three dimensions.

Click on any item ID in the table to view the student version of the item. To return to this index page, click on the Measured Progress logo at the upper left corner of the student item page. Page numbers refer to where the items are located in the Scoring Guide.

<table>
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<th>Item ID</th>
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Connections to Common Core State Standards

Every STEM Gauge Elementary topic-based item set includes a table that shows suggested connections to the Common Core State Standards (CCSS). For those items that offer connections, you will find the standards at the bottom of the Scoring Notes within the Scoring Guide of each item.

Some topic-based item sets also contain items written to an ELA passage. For these sets, ELA connection sets are available. These ELA Connection sets use the same passages and provide teachers with bonus ELA items.

---

**Suggested Connections to Common Core State Standards**

<table>
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<tr>
<th>Item ID</th>
<th>Page No.</th>
<th>Type</th>
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<th>Mathematics CCSS</th>
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---

Omar has a beaker of water like the one shown.

a. Draw a model of the structure of the water in the beaker.
b. Explain your model.

**Connections to Common Core State Standards**

CCSS.MP.3: Construct viable arguments and critique the reasoning of others.
W.5.2 Grade 5: Writing: Text Types and Purposes: Write informative/explanatory texts to examine a topic and convey ideas and information clearly.
Scoring Guide and Student Items

Each **STEM Gauge** Elementary topic-based item set includes a Scoring Guide. The Scoring Guide shows the NGSS alignment, the DOK level, and the item’s ID number. For all items except K–1 activities, the scoring guide provides a snapshot of the student version of the item (which may show a smaller graphic than in the actual student version). Complete scoring information for CRs and ERs includes the scoring rubric and possible student responses. MC item scoring information includes indication of the correct answer and distractor rationales. For all item types, suggested connections to the CCSS appear.

**Sample scoring information for each item type is shown below.**

### Constructed-Response Rubric

<table>
<thead>
<tr>
<th>Level of Understanding</th>
<th>Evidence of Understanding</th>
</tr>
</thead>
</table>
| 2 Demonstrating Expected Understanding | Student response provides **clear** evidence of using the dimensions* to make sense of scientific phenomena and/or to design solutions to problems. Student is able to:  
• explain what the model tells about the four main Earth systems;  
AND  
• identify two things that are part of each Earth system. |
| 1 Progressing toward Understanding | Student response provides **partial** evidence of using the dimensions* to make sense of scientific phenomena and/or to design solutions to problems. The response lacks some critical information and details or contains some errors. Student is able to:  
• explain what the model tells about the four main Earth systems **BUT** the identification of two things that are part of each Earth system contains errors or is not provided;  
OR  
• identify two things that are part of each Earth system **BUT** the explanation of what the model tells about the four main Earth systems contains errors or is not provided. |
| 0 Not Showing Understanding | Student does not respond or student response is inaccurate, irrelevant, or contains insufficient evidence of using the dimensions* to make sense of scientific phenomena and/or to design solutions to problems. |

*As outlined in the Performance Expectations (PE) of the NGSS, the three dimensions are the disciplinary core ideas (DCI), science and engineering practices (SEP), and crosscutting concepts (CCC). Note that due to the complexity of the PEs, individual assessment items may not address all three dimensions.

### Scoring Notes

Possible answers include:

a. The four main Earth systems overlap and affect each other.

b. [The components of each system include the following, from which two should be identified for each system:]
• atmosphere—air (gases) and wind  
• geosphere—soil, sediments, rocks, lava, continents, mountains  
• hydrosphere—water, ice, rivers, lakes, glaciers  
• biosphere—animals, plants (all living things)

### Connections to Common Core State Standards:

MP4: Model with mathematics.

Student versions of the items appear after the Scoring Guide.
ELA Connection Item Sets

Like many elementary teachers, you may teach English language arts and math as well as science. You may have difficulty finding time to teach science. In addition, new standards emphasize and raise expectations for student language and literacy development across all domains. The diagram below shows the overlap between the language and literacy practices found in the Common Core State Standards (CCSS) and the NGSS. The resources in the ELA Connection item sets help you integrate your ELA and science instruction.

Overlap between CCSS for ELA and NGSS Science and Engineering Practices


We have a bonus for you. Some STEM Gauge Elementary item sets are coupled with English language arts passages. To supplement these science items, we offer an ELA Connection set that provides you with ELA items that are created and linked to the same passage and aligned to grade-appropriate CCSS. The following STEM Gauge Elementary topic-based item sets have supplementary ELA Connection sets.

Grade 5
- Structure and Properties of Matter
- Earth’s Systems
- Space Systems: Stars and the Solar System

Grade 4
- Energy
- Waves: Waves and Information
- Structure, Function, and Information Processing
- Earth’s Systems: Processes that Shape the Earth

Grade 3
- Interdependent Relationships in Ecosystems: Environmental Impacts on Organisms
- Inheritance and Variation of Traits: Life Cycles and Traits

K–2
- Life Science

ELA and Science
- EP4. Build and present knowledge through research by integrating, comparing, and synthesizing ideas from text
- EP5. Build upon the ideas of others and articulate their own clearly when working collaboratively
- EP6. Use English structures to communicate context-specific messages
- EP7. Use technology and digital media strategically and capably
- EP1. Support analysis of a range of grade level complex texts with evidence
- EP2. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience
- EP3. Construct viable and valid arguments and critique reasoning of others
- SP7. Engage in argument from evidence
- SP8. Obtain, evaluate, and communicate information
- SP1. Ask questions and define problems
- SP2. Develop and use models
- SP3. Plan and carry out investigations
- SP4. Analyze and interpret data
- SP5. Use mathematics and computational thinking
- SP6. Construct explanations and design solutions
Instructional Strategies

Effective formative assessment strategies are highly interactive and designed so that the same instructional activities that support students’ learning also yield evidence of students’ progress. Within this STEM Gauge Teacher’s Guide, we have diagrammed this instruction and feedback cycle. Centered around the NGSS, and with the goal of helping students gain mastery toward the PEs by the end of instruction, the instructional strategy begins with engaging students in learning.

1. **Engage students in learning**
   
   Student engagement directly affects student learning. Students become more invested in the learning process when they are encouraged to ask questions and actively participate in discussions about their own thinking.

2. **Elicit evidence of understanding**
   
   Evidence can be defined as observable features of student performance and can be gathered in a variety of ways. Students’ responses provide evidence about their understanding and progress toward meeting PEs.

3. **Interpret the evidence and identify gaps in understanding**
   
   Teachers and students interpret the collected evidence to determine where the students are in relation to the learning goals. Analysis and interpretation of evidence is ongoing and is used to monitor progress and inform instructional next steps.

4. **Gather and provide feedback**
   
   Actionable feedback keeps learning moving forward. When students receive timely, descriptive feedback, they understand what they need to do next and their performance improves. This kind of effective feedback also supports students’ metacognition, or awareness about their own thinking.

5. **Plan learning and instructional modifications**
   
   Collected evidence and feedback can be used to inform and modify lesson plans while teaching and learning is still occurring. Instruction can be targeted to address specific misconceptions or learning needs.

6. **Scaffold new learning**
   
   Teachers can support students’ transition to the rigor of the NGSS by translating the PEs into learning targets. When teachers provide additional clarification and guidance through modeling and feedback, students gain a greater understanding of what is expected.

---

So how does this cycle of effective formative assessment translate into your classroom?

Lessons need to engage students with real-life phenomena or relevant problems that raise questions in students’ minds that they can figure out. Both you and your students need to know where you are going in order to have clear learning targets and criteria to measure success.

You need ways to:
- collect evidence of your students’ learning over time.
- respond to the evidence you collect during instruction.
- provide effective feedback to your students.

Students need ways to:
- think about their own learning.
- assess their own understanding.
- assess the learning of their classmates.

You and your students need to collaborate as partners in learning.
Anchoring Phenomenon and Relevant Problems

Introducing your lesson with an engaging anchor phenomenon or a relevant problem will help focus your instruction.

Where can you get suggestions for phenomena or relevant problems?

- Your students
  - Pay attention to their interests and link these interests to their learning.
  - What do they ask you questions about? Make a list of topics they bring up.
- The news—especially local news that affects your students’ daily lives
- The website, Phenomena for NGSS—an online collection of phenomena aligned to NGSS topics chosen specifically for use in the classroom

How do you identify a great phenomenon or problem to engage your students?

<table>
<thead>
<tr>
<th>Key Features of an Engaging Anchor</th>
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</thead>
<tbody>
<tr>
<td><strong>Accessible</strong></td>
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<tr>
<td>Your students can</td>
</tr>
<tr>
<td>• observe it</td>
</tr>
<tr>
<td>• ask testable questions about it</td>
</tr>
<tr>
<td>• design and perform investigations with it</td>
</tr>
<tr>
<td>• work toward making sense of it</td>
</tr>
<tr>
<td><strong>Relevant</strong></td>
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<tr>
<td>• Moves toward understanding of the performance expectation</td>
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<tr>
<td>• Takes place in the real world</td>
</tr>
<tr>
<td>• Builds on students’ experiences</td>
</tr>
<tr>
<td>• Engages scientific and engineering practices</td>
</tr>
<tr>
<td>• Has importance and meaning to your students</td>
</tr>
<tr>
<td><strong>Generative</strong></td>
</tr>
<tr>
<td>• Generates more questions</td>
</tr>
<tr>
<td>• Promotes deeper thinking</td>
</tr>
<tr>
<td>• Stimulates continuing learning about the phenomenon after the lesson</td>
</tr>
<tr>
<td><strong>Ethical</strong></td>
</tr>
<tr>
<td>Does no harm to any living things</td>
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</table>

Consider encouraging children to notice things in their own environments that they may have questions about:

- How does my bike work?
- Why is this plant turning yellow?
- Why do some birds flock together but you see others alone?
- Why is it hot in summer?
- Why do leaves turn color in the fall?

How can young children’s questions become an anchoring phenomenon to a lesson or activity? Connect their natural interests to the PEs you need to teach.

Assessment Items

Assessment items, embedded in your instruction, can engage students in new content and help both you and your students assess 3-dimensional learning before, during, or after learning about a topic. STEM Gauge Elementary items are designed to be used as you teach. They are NOT intended to be made into tests at the end of instruction.

View examples of different item types here.
Elicit evidence of understanding

Use STEM Gauge Elementary items and formative tools to gather evidence of understanding from your students. For example, during instruction, distribute a multiple-choice question. Ask your students to first think about the question by themselves, then pair with another student and discuss the options. Encourage them to practice their reasoning skills. Why did they select a particular option as the correct response?

While the students are still in pairs, share the distractor rationales with them. This will help your students see where they are in their understanding of this item.

Multiple-choice (MC) questions can provide a quick check of learning that will generate evidence of understanding. Students may respond to a check-in to elicit understanding of a MC item with student clickers, individual student whiteboards, or the four corners strategy.

Using the four corners approach, each option can be represented by a different corner of the classroom. Students who gather in each corner can collaborate to explain why they chose that particular option. This activity provides students with practice in constructing explanations and communicating information. Because the SEPs are a continuum and not discrete from one another, you can probably spot some other practices, besides the one mentioned in the PE, that students engage in as they answer this question.

Sharing answer keys and distractor rationales from multiple-choice items, and sharing rubrics and scoring notes from constructed-response and extended-response items, will help you and your students identify misconceptions or clarify why a response is incorrect. Use these items to provide the opportunity for students to self-assess and learn.

Distractor Rationales

A. Key. The observation that rose plants with thorns are taller than rose plants without thorns supports Cora's claim because deer most likely eat the rose plants without thorns, making the plants shorter.

B. This would possibly refute the claim, as it suggests that plant parts on rose plants without thorns are less likely to be eaten than parts of plants with thorns.

C. This would possibly refute the claim, as it suggests that plant parts on rose plants without thorns are less likely to be eaten than parts of plants with thorns.

D. This would not refute or support the claim because it is not a result of the experiment; it was part of the experimental design.
Puffins are endangered seabirds that eat fish and build nests on rocky ground. On the Isle of May, a rocky island, puffins had two main problems:

- **Seagull problem:** Seagulls eat puffin eggs from the ground nests.
- **Human problem:** Humans hunt puffins for food and feathers.

The people of the island took actions to help the puffins. The chart describes the actions and the results.

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Puffins</th>
<th>Information</th>
</tr>
</thead>
</table>
| 1959 | Less than 100     | • Puffins migrate to the island  
• Hunting is not allowed; island becomes a nature park |
| 1972 | Unknown           | • 17,000 seagull nests in 1972  
• Humans begin 14-year plan to stop seagulls from nesting on island |
| 1990 | Unknown           | • Less than 4,000 seagull nests |
| 2013 | 92,000            | • More puffin eggs have hatched every year since 2013 |

a. Make a claim about the effect that the people’s actions listed in the chart had on the puffins.
b. Identify evidence from information in the chart that supports your claim in part (a).
c. Explain why the people’s actions listed in the chart had an effect on the puffins.
**Gather and Provide Feedback**

Actionable feedback keeps learning moving forward. When students receive timely, descriptive feedback, they understand what they need to do next, and their performance improves. This kind of effective feedback also supports students’ metacognition, or awareness about their own thinking.

**STEM Gauge** Elementary provides a variety of metacognitive tools. These help students with the important practices of thinking about their learning and describing where they think they are along the path of understanding. Perhaps the students think they understand, but other evidence, which teachers can share with them, shows that there may still be gaps in their understanding. This give and take provides an opportunity to discuss what the student needs to do to achieve mastery of the PE.

**Plan Learning and Instructional Modifications**

**STEM Gauge** Elementary provides a Formative Assessment Review Plan that follows the same formative assessment steps outlined in this section of the Teacher’s Guide. Use this plan to help you design instruction that engages students, elicits evidence of understanding, provides ways to gather and interpret evidence of understanding, provides timely and effective feedback, and results in ideas for instructional modifications and scaffolding new learning.

**Scaffold New Learning**

A Framework for K–12 Science Education describes the progression of disciplinary core ideas (DCI) in the grade band endpoints. Built on this framework, the NGSS is designed so that students progress in their learning of key DCIs through the grades. Appendix E of the NGSS makes these learning progressions explicit and is helpful in identifying where your students have been and where they need to go in their learning. **STEM Gauge** Elementary is organized by topics. This organization makes it easy for you to choose items of varying difficulty as needed to address specific students’ learning needs. Look at the table of **STEM Gauge** Elementary topic-based item sets to see where topics repeat in multiple grades.
Formative Support Tools Overview

The tools provided in STEM Gauge help engage students and support teachers in the formative assessment process.

Metacognitive Tools

Providing students with time to reflect on their own learning (metacognition) is critical to deepening their understanding of the NGSS PEs. STEM Gauge Elementary offers a variety of tools to support metacognition. As a teacher, you can select the tool you think best fits your students and the particular PE they are currently studying.

Student Self-Assessment Gauge

This tool gives students the prompt “I can…” to describe their accomplishment of the student learning target. Then, students gauge their own learning by drawing an arrow on the gauge graphic, indicating their own assessment of their current level of understanding. Space is provided for students to write questions they may still have about this target.

Stoplight Self-Assessment

This tool is similar to the Student Self-Assessment Gauge. It gives students the prompt “I can…” to describe their progress toward the Student Learning Target. Then, students select which circle of the traffic light best indicates their current level of understanding. Space is provided for students to write questions they may still have about the Student Learning Target.

You can use the stoplight idea for quick check-in, too. Your students can use colored popsicle sticks, a stack of colored cups on their desk, or other visual representations of red, yellow, and green to quickly give you a sense of their self-assessment of a particular Student Learning Target. You may want to scaffold this metacognitive concept by first using concrete colored objects and then using the Stoplight Self-Assessment when students are familiar with the idea.

Draw and Explain

Asking your students to draw and explain a concept is not only a great way for students to reflect on their learning but is also a great way to reveal their thinking. Errors and misconceptions are uncovered so that you can modify your instruction and provide timely feedback to your students.

Student Self-Assessment of 3-Dimensional Learning (3D Mobile)

This tool helps students reflect on the particular science and engineering practices (SEP) and crosscutting concepts (CCC) they used to engage in learning about a disciplinary core idea. Space is provided within the tool for students to write down what they did (SEP), what they know (DCI), and how they think (CCC) about a student learning target. Teachers may want to provide lists of the SEPs and the CCCs as references for students. After students have finished writing, they can cut out the different parts of the tool and assemble a three-dimensional mobile that represents their learning. If desired, the different strips that compose the 3D mobile can be colored to represent the color coding of the NGSS. The instructions to assemble the mobile are located on the student version of the tool.

Print the Formative Tools >>
Mapping Tools

Two mapping tools are provided. These mapping tools each have two benefits: they support students’ thinking and learning and reveal the students’ thinking to you.

**Cause and Effect Map**

Cause and effect is a predominant crosscutting concept in NGSS performance expectations for K–5. For this reason, **STEM Gauge Elementary** includes a Cause and Effect Map to help support student learning of this fundamental concept. Students identify the causes down one side and then map the effects down the other side to show the relationships. Use this tool along with **STEM Gauge Elementary** items designed to assess PEs that include cause and effect.

**Claim, Evidence, and Reasoning Map**

Engaging in argument from evidence is a predominant science and engineering practice found within the NGSS PEs for K–5. **STEM Gauge Elementary** includes a Claim, Evidence, and Reasoning Map to support students as they think about their claims, provide evidence to support their claims, and construct their reasoning. Use this tool along with **STEM Gauge Elementary** items designed to assess PEs that engage students in the practice of arguing from evidence.

Feedback Tools

Feedback is critical for effective teaching and it goes two ways. Students can provide feedback to teachers to help teachers assess their teaching and modify instruction, and teachers can provide feedback to students to deepen students’ learning experiences. **STEM Gauge Elementary** provides two specific feedback tools. (The metacognitive tools also provide helpful feedback to both teachers and students.)

**3-2-1 Feedback**

Use this tool at the end of instruction to assess students’ learning and modify instruction. Students provide feedback to you by listing three things they learned, two things they found interesting or that surprised them, and one question they still have. This tool may be useful as an exit slip.

**Stars and Steps Formative Feedback**

Use this tool to provide feedback to students. This tool provides students with feedback on areas of strength and mastery within the learning target, and on areas that require additional learning or more focus within the learning target. Directions for using this feedback tool are included in the Formative Tools packet.

Formative Assessment Review Plan

This tool helps you plan your instruction around the core strategies in the formative assessment cycle. You can modify your plan as you receive feedback and employ strategies to engage and assess your students during instruction.
Activities Overview for K–2

If you are a K–2 teacher, you may have come to this section first. That’s great! This section supplements the other sections in this Teacher’s Guide.

For kindergarten and grade 1, STEM Gauge Elementary offers activities along with conventional item types. Activities are specifically designed to engage students in 3-dimensional learning as they explore a particular phenomenon or seek a design solution.

These activities may involve the whole class, small groups, or individual students. Activities are flexible and may be adapted to local phenomenon and/or design problems that are more familiar to students. Each activity provides:

- background information
- a complete list of materials needed
- an estimated time frame for completion
- a complete teacher’s script and possible correct student responses
- any student worksheets and/or handouts needed to do the activity
- rubrics
- observational checklists (where appropriate)

Although activities have detailed instructions and may be adapted to local phenomenon and/or design problems that are more familiar to students. For an annotated sample activity, click here.

We encourage you to take observational notes during class discussions on what students know and can do. We’ve provided a space at the bottom of every page of the activities PDF for this purpose.

To help you plan your science classroom instruction, the tables below offer information about the activities in each K–2 STEM Gauge Elementary topic set. You will see that activities vary in length, content, and how they can be used in the classroom. Because the NGSSs are built on learning progressions, you can use items on similar topics in other STEM Gauge Elementary topic sets for more advanced students.

<table>
<thead>
<tr>
<th>Grade</th>
<th>PE</th>
<th>Item ID</th>
<th>Description*</th>
<th>Estimated Time</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>K-PS3-1</td>
<td>466773</td>
<td>W, I</td>
<td>40 minutes</td>
<td>Sunlight’s effect on different surfaces</td>
</tr>
<tr>
<td></td>
<td>K-PS3-2</td>
<td>466781</td>
<td>W, S</td>
<td>30–90 minutes, can be spread out over multiple days</td>
<td>Designing a structure to reduce the warming effect of sunlight</td>
</tr>
<tr>
<td></td>
<td>K-ESS2-1</td>
<td>466692</td>
<td>W, I</td>
<td>Daily activity for one month, 3–10 minutes per day</td>
<td>Weather patterns over time</td>
</tr>
<tr>
<td></td>
<td></td>
<td>466762</td>
<td>I</td>
<td>5 minutes per student</td>
<td></td>
</tr>
<tr>
<td></td>
<td>K-ESS3-2</td>
<td>513033</td>
<td>W, S, I</td>
<td>2–3 sessions, 15–20 minutes per session</td>
<td>Purpose of weather forecasting to prepare for, and respond to, severe weather</td>
</tr>
<tr>
<td>1</td>
<td>1-ESS1-1</td>
<td>466689</td>
<td>W, I</td>
<td>5 minute daily activity 3x per day for 6–8 days; 70 minutes for introduction, analysis, and discussion</td>
<td>Pattern of the Sun’s movement through a day</td>
</tr>
<tr>
<td></td>
<td></td>
<td>496990</td>
<td>W, S, I</td>
<td>50 minutes</td>
<td>Patterns of the Sun’s, the Moon’s, and Earth’s movements</td>
</tr>
<tr>
<td></td>
<td></td>
<td>496991</td>
<td>W, I</td>
<td>40 minutes</td>
<td>Patterns of daytime and nighttime skies</td>
</tr>
<tr>
<td></td>
<td>1-ESS1-2</td>
<td>464518</td>
<td>W, I</td>
<td>10 to 15 minutes per month, for 6–9 months; Final class discussion: 15 to 20 minutes</td>
<td>Daylength patterns related to seasons</td>
</tr>
</tbody>
</table>

* W = whole group, S = small group, I = individual

Other Item Types

For descriptions of multiple-choice, constructed-response, and extended-response items, please click here. These items can be embedded in classroom instruction to engage students and to assess learning during instruction. The formative support tools provided in STEM Gauge Elementary are also designed to be used during instruction and in conjunction with the various item types.
Suggested Resources


Next Generation Science Exemplar System for Professional Development, or NGSS 2.0 http://www.ngssx.org/.


The following sources provide additional lists of resources that you might find helpful:


Notes


2. Bybee, R.W. (2016). NGSS innovations. (Bybee, 2016: “To capture these innovations in a few words, the NGSS integrates three-dimensional learning; emphasizes student experiences with phenomena; includes performance expectations; includes the nature of science and engineering with traditional science content; describes learning progressions for grades K through 12; and makes connections between science and English-language learning and mathematics.” http://www.amnh.org/explore/curriculum-collections/five-tools-and-processes-for-ngss/introduction/foreword-by-rodger-w.-bybee/)


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