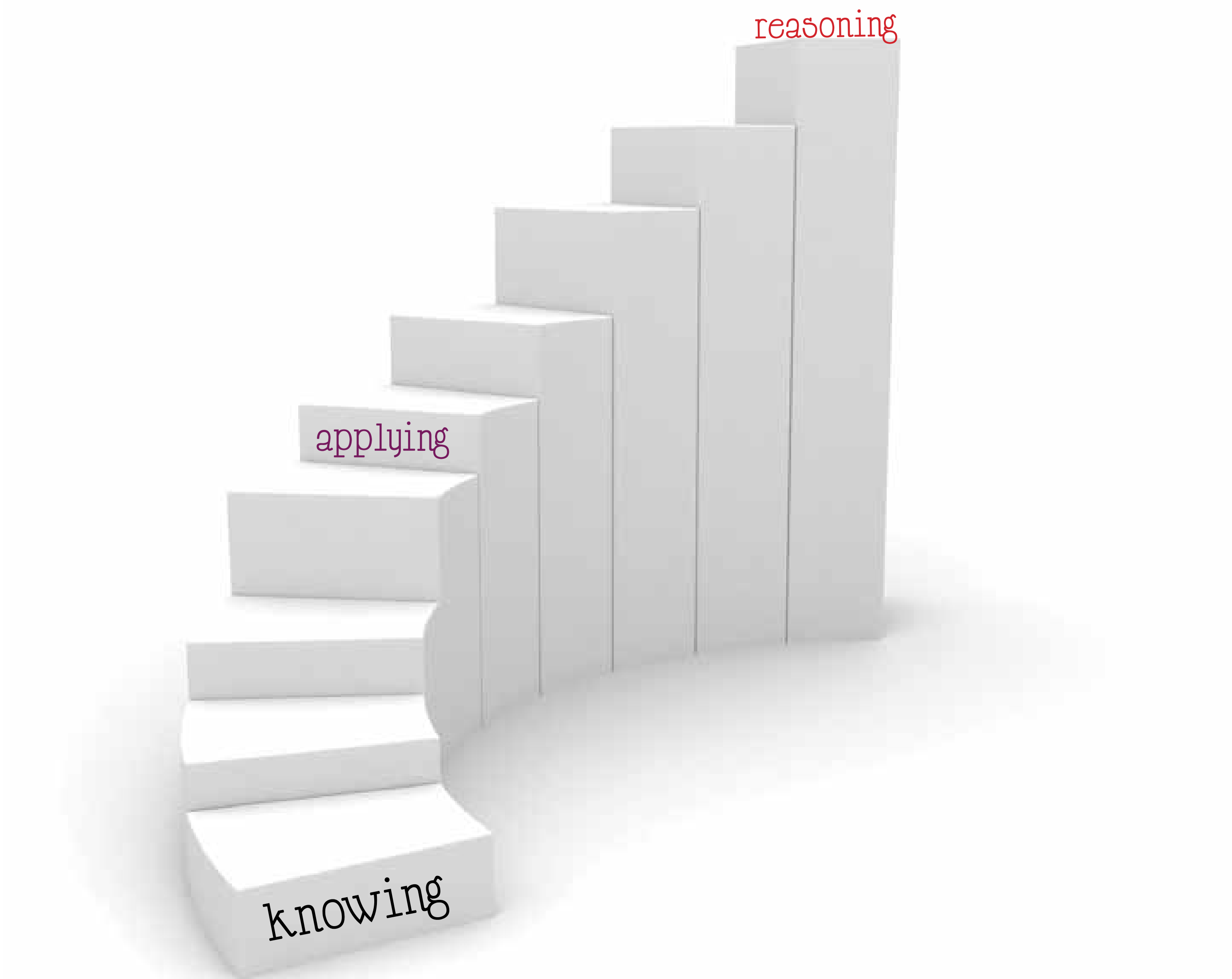


by Dina Drits-Esser and Megan Black

Standardized Test Questions

A Tool for Developing Students' Proficiency With the *Framework*'s Science Practices

As part of a team leading an inquiry-based professional development program for teachers, we were reluctant when asked to present a workshop on a dreaded topic: assessments and standardized tests. How could we tie standardized testing to the inquiry science we were encouraging teachers to adopt? As we began exploring released standardized test items from our state and national assessments, however, we found that many questions support the inquiry and higher-order thinking skills we were advocating for in the program.

Teachers can use higher-level-thinking test items during everyday classroom instruction to build students' facility with inquiry and a number of the science practices outlined in *A Framework for K–12 Science Education* (NRC 2012). Further, these items can be used before, during, and after instruction throughout the year as formative assessments and to promote meaningful classroom discussions.

In this article, we describe strategies for finding higher-level-thinking test items from internet-based test-item banks and explain how to identify quality items that align to the principles outlined in the *Framework* and the *Next Generation Science Standards (NGSS)* (NGSS Lead States 2013). We also provide strategies for using these items in your classroom throughout the year as discussion starters, rich formative assessments, and tools for reducing test anxiety for both you and your students. (Also see "Every Assessment Tells a Story" in this issue.)

Finding released test items

The first step to using test questions in your classroom is to collect questions. Released test items from international and national assessments, such as the Trends in International Mathematics and Science Study (TIMSS) and National Assessment of Educational Progress (NAEP), from the American Association for the Advancement of Science (AAAS), and from state assessments are easily accessed on the internet. The validity, or measurement of what a test claims to measure, and reliability, or consistency of a measure, of these items have already been established through field testing and statistical analysis. Therefore, you can be sure the items will measure the science practices and content that you intend for them to measure.

While some released test items rely on simple memorization, many others require critical thinking, analysis, application, and other science process skills. These skills align with many of the practices outlined in the *Framework* and *NGSS*, including Asking Questions; Using Models; Planning and Carrying Out Investigations; Analyzing and Interpreting Data; Using Mathematics and Computational Thinking; Constructing Explanations; Engaging in Argument from Evidence; and Ob-

FIGURE 1 Example of a knowing item (IEA 2013)

A gas is heated and its temperature increases. What happens to the gas molecules?

a. They get bigger.

b. They move faster.

c. They move slower.

d. They increase in number.

taining, Evaluating, and Communicating Information (NRC 2012; NGSS Lead States 2013).

Classifying released test items: Cognitive domains

In order to understand and identify the types of skills test items assess, it is useful to classify them. We use a structure for classifying items from the cognitive domains used in the TIMSS 2011 assessments: knowing, applying, and reasoning (Mullis et al. 2009).

Knowing

Most tests include some *knowing* questions, which focus simply on recall and vocabulary acquisition and do not require higher-order thinking. In the knowing question in Figure 1, students must know how molecules respond to external sources of heat. Students either have or do not have the background knowledge to answer the question. Knowing questions are useful because you can directly assess your students' knowledge of scientific facts.

Applying

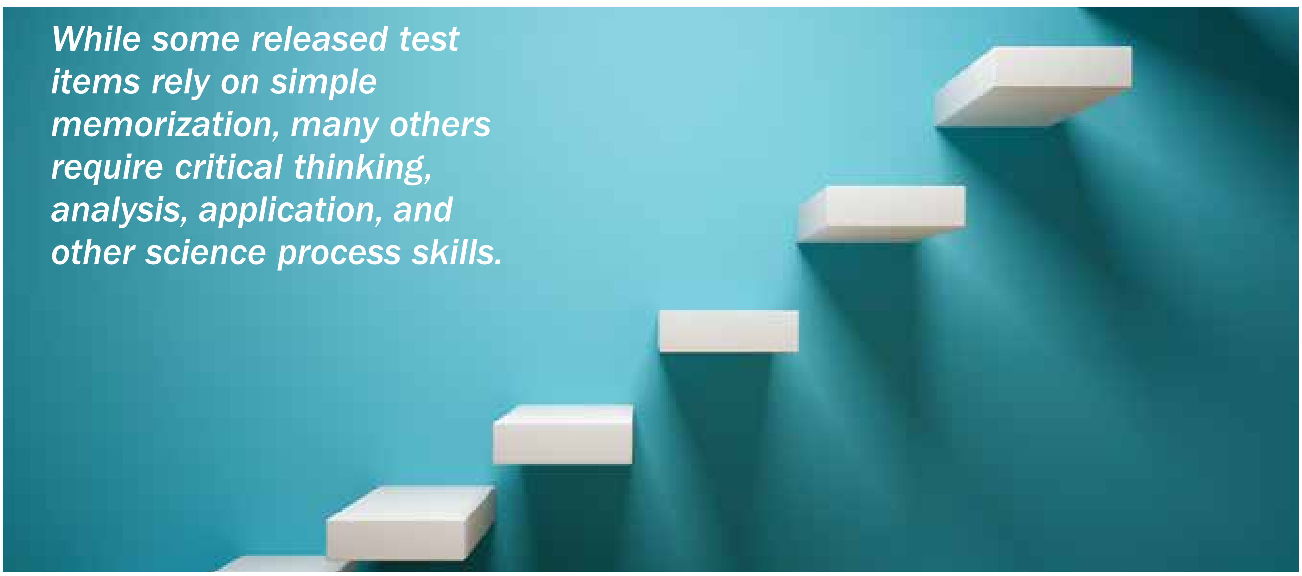
Applying questions require higher-order thinking because they assess students' understanding of larger concepts and their ability to make connections between concepts. To correctly answer these questions, students must apply science knowledge and conceptual understanding to a scientific problem.

The applying item in Figure 2 assesses students' conceptual understanding of eclipses and Moon phases. To answer this question, students must understand the definition of an eclipse, the alignment of the Moon, Earth, and Sun during an eclipse, and how the Moon's orbit relates to Moon phases. Students must then apply this understanding to a scientific problem—in this case a what-if scenario. The question requires students to explain why eclipses do not occur each month, and then to think backward to figure out what would occur if the Moon were aligned with the Earth and Sun.

This item can be used to evaluate students' ability to use practices outlined in the *Framework* and *NGSS,* including Using Models and Constructing Explanations. Students must use and make sense of a model to interpret the unique scenario posed by the question and then select the correct explanation.

Reasoning

Reasoning questions also require higher-order thinking, as students combine content knowledge with process skills and use scientific reasoning to construct their explanations. These items assess stu-



dents' ability to analyze and interpret data, evaluate experimental designs, solve problems, and apply their understanding of science concepts and practices to novel situations.

To answer the reasoning question in Figure 3, students must possess the background knowledge to understand that changing a biotic factor will influence other parts of an ecosystem. Students must use this knowledge to interpret a diagram of a novel change in an ecosystem and then predict how the change will affect other organisms in the ecosystem. This item requires additional higher-order thinking because students are required to take their thinking beyond the direct impact of eliminating the top predator, foxes, on their prey to the impact this change will have on the trees, one of the producers in the food web.

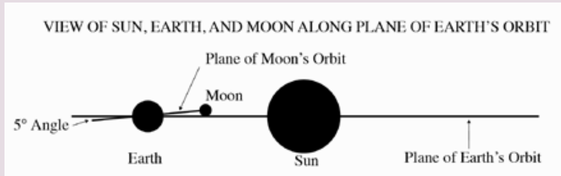
This question addresses several practices described in the *Framework* and *NGSS*, including Evaluating Information and Constructing Explanations. Students must evaluate data to choose the best explanation of what will occur in this ecosystem under certain conditions.

Using released test items for classroom instruction

Once you have identified released items that require higher-order thinking and include science practices, you can use these questions during everyday instruction. Integrating released test items into your lessons throughout the year will help your students both master the science practices identified in the *Framework* and *NGSS* and feel more prepared for standardized tests. Next, we describe three strategies for incorporating released test items into your lessons.

FIGURE 2 Example of an applying item (NCES 2011)

Earth revolves around the Sun, and the Moon revolves around Earth. The Moon's orbital path is sometimes above and sometimes below the plane of Earth's orbit, as shown in the diagram below.



What would happen if Earth's orbit and the Moon's orbit were in the same plane?

a. Eclipses would occur every month.

b. The Moon would not have phases.

c. All sides of the Moon would be visible from Earth.

d. The same side of the Moon would always face the Sun.

Exit tickets

Most middle-level science teachers are familiar with exit tickets, short written responses to questions that teachers pose at the end of a lesson. These responses are often called *exit tickets* because many teachers gath-

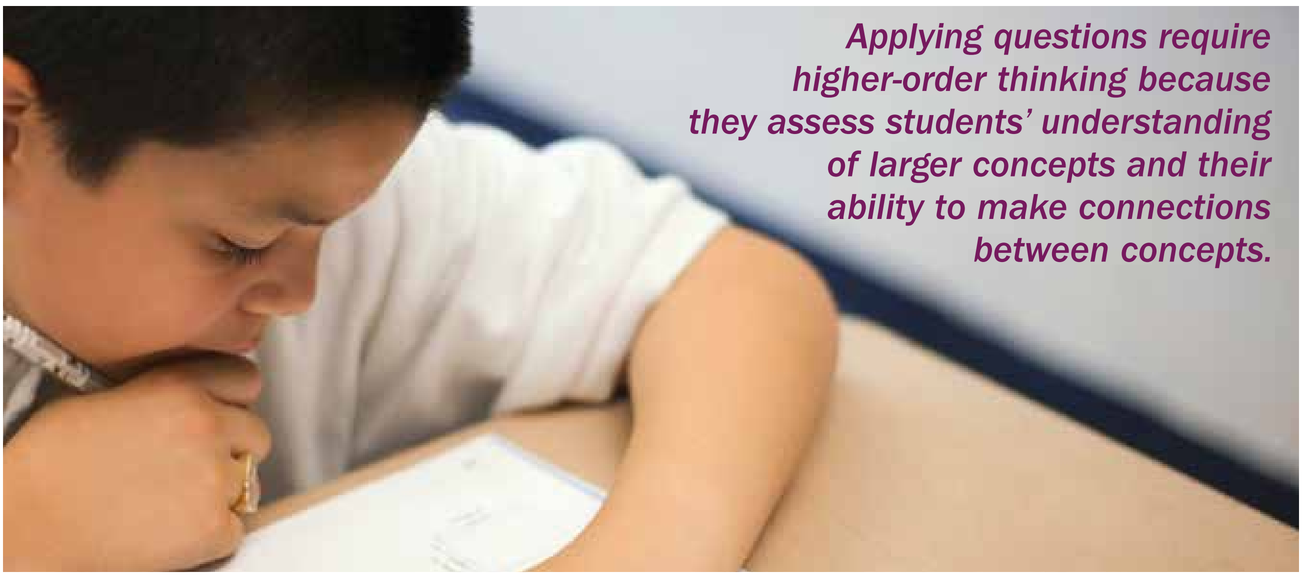
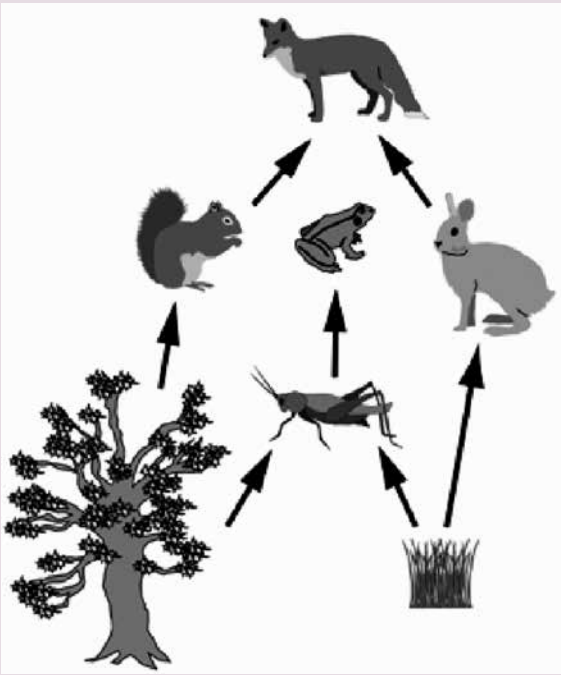


FIGURE 3 Example of a reasoning item (MOSART 2011)

In a forest ecosystem (see picture below), squirrels eat plant material and foxes eat squirrels.



What would probably happen to the amount of plant material in this ecosystem if all the foxes suddenly died? At first, the amount of plant material would

a. not change because foxes do not eat plants.

b. not change because other animals would move in to eat the squirrels.

c. decrease because the number of surviving squirrels would increase.

d. increase because there would be more room for plants to grow.

e. decrease because foxes protect the plants.

er them at the door as students leave the classroom.

Using released test questions to develop exit tickets will ensure that your students are familiar with the diagrams and vocabulary found in national and state standardized tests. Exit tickets also provide accessible and immediate data on student learning, allowing teachers to be responsive to individual student needs.

To create an exit ticket from a released test item, choose an applying or reasoning question. Questions that require students to use both content knowledge and science practices will provide you with more data to effectively design instruction that addresses student misunderstandings. The reasoning item in Figure 4 requires students to understand the climatic factors that define a jungle biome and to analyze and interpret precipitation and temperature data that are embedded in a diagram.

To assess student understanding of this question, you might sort the responses into four groups: answered the question correctly and provided adequate reasoning; answered the question correctly but did not provide reasoning; answered the question incorrectly because student does not know the climatic factors in a jungle biome; and answered the question incorrectly because student was unable to gather the necessary data from the diagram.

Depending on how many student responses fall in each group, you could choose to teach a mini-lesson about biomes or interpreting diagrams. Or you could differentiate, working with small groups of students to address specific misunderstandings.

Prompts

Released items that address common misconceptions can be changed into prompts, in which students are asked to select the correct answer to a question and then to explain their reasoning. Like exit tickets,

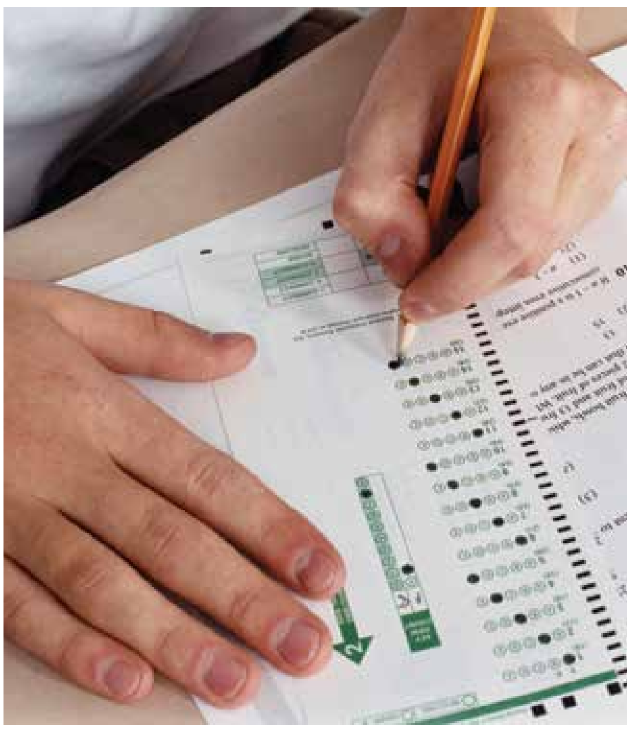
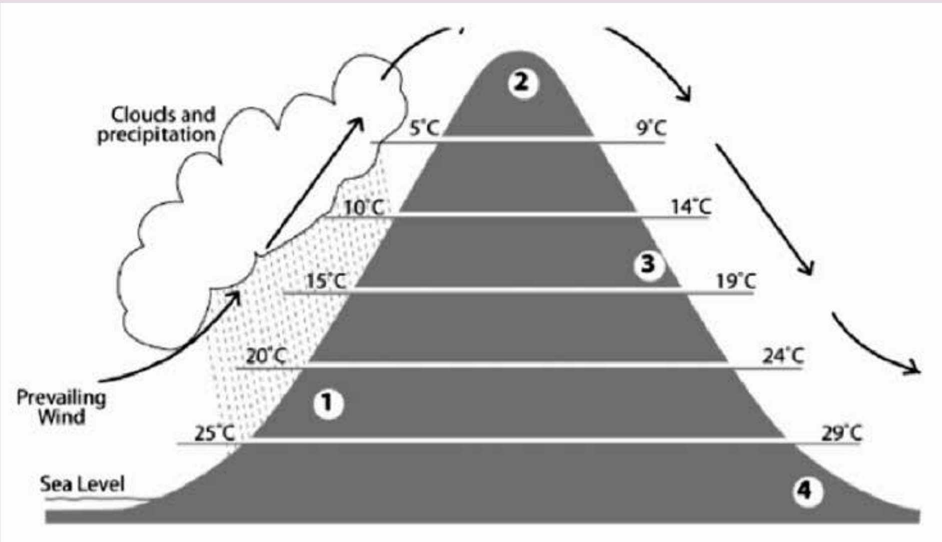


FIGURE 4 Exit ticket questions (IEA 2013)



The diagram above shows the prevailing wind direction, precipitation, and average air temperatures at different elevations on both sides of a mountain. In which location are you most likely to find a jungle? Explain your reasoning.

a. Location 1 b. Location 2 c. Location 3 d. Location 4

prompts provide more insight into student thinking than a multiple-choice question, because students must explain, either orally or in writing, why they chose a particular answer.

To create a prompt, choose an applying question and add details to transform the question stem into a story. Then assign a student name to each answer choice and ask your students to choose which student they agree with and why.

In the prompt in Figure 5, we changed an applying question about light into a story about two neighbors. In order to answer this question correctly, students need to understand that we see objects that reflect light and use this understanding to construct an explanation of why Julia, who is outside, cannot see Amanda inside the house. While many light units involve reflection investigations, students do not always connect reflection in an investigation and the role of reflection in seeing everyday objects. This prompt allows teachers to assess students' conceptions of light and our ability to see objects.

Prompts can also be easily modified for special needs students by reducing the number of answer choices the student needs to evaluate. Instead of requiring a student to select from four answer choices, leave only the correct answer choice and an answer choice with a common misconception; the reduced prompt will still allow you to assess student understanding.

One way to use prompts in everyday instruction is to begin class with a prompt and discuss the prompt after students have constructed their explanations, which allows teachers to immediately address student misconceptions. Because prompts make student thinking transparent, teachers can effectively develop activities that lead students to scientifically accurate understandings.

FIGURE 5 Sample question and prompt (IEA 2005)

Sample question
A person in a dark room looking through a window can only clearly see a person outside in the daylight. But a person outside cannot see the person inside. Why does this happen?

a. There is not enough light being reflected off the person in the room.
b. Light rays cannot pass through a window twice.
c. Outside light does not pass through windows.
d. Sunlight is not as intense as other sources of light.

Light prompt
Amanda and Julia are neighbors. Julia is outside playing in front of Amanda's house. Amanda is looking out the window at Julia from a dark room in her house. Amanda can clearly see Julia outside playing in the daylight. Julia cannot see Amanda inside the house. How does this happen?

Read students' responses below. Choose the student with whom you most agree and explain why you agree with that student.

- Zoe says, "There is not enough light being reflected off of Amanda in the room."
- Chase says, "Light rays cannot pass through a window twice."
- Stephanie says, "Outside light does not pass through windows."
- Isaac says, "Sunlight is not as intense as other sources of light."

Evidence circles

Another strategy to use with released test questions is evidence circles. In an evidence circle, students participate in a structured discussion about a question that relates to a recent concept or unit the class has studied. These discussions expose students' ideas about scientific concepts and reveal their ability to make connections between investigations from the unit and real-world scenarios.

To develop an evidence-circle activity, choose an applying or reasoning question, print the question, and then cut the stem and answer choices into strips and place these in an envelope. Small groups of four or five students receive an envelope; all groups should receive the same question. Ask each student to pull a strip of paper from the envelope and have students take turns reading the question and answer choices aloud to their group. Requiring everyone in the group to read aloud ensures that all group members are involved and encourages reluctant students to join the discussion.

After students read, the small groups discuss the best answer choice and defend their choice with evidence from previous investigations students have conducted throughout the unit. Encouraging students to use data from their science notebooks to support their answer choice helps them to develop argumentation skills.

You can then facilitate a whole-class discussion by asking each group to share its answer choice and evidence with the class. Be sure to ask groups probing questions about their evidence, leading *students* to determine the best answer choice.

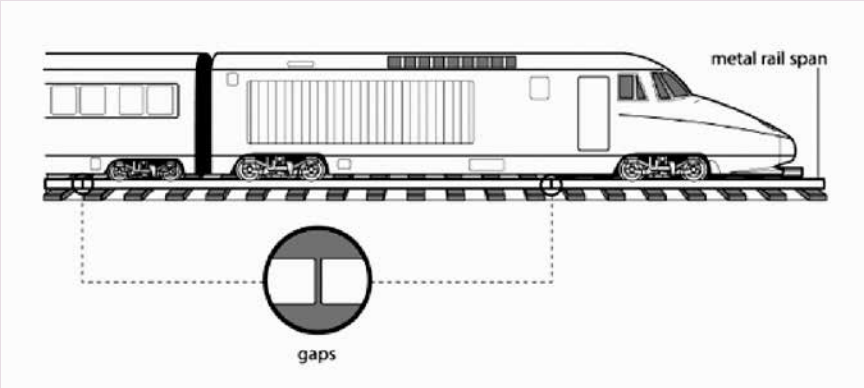
The applying question in Figure 6 could be used as an evidence-circle activity within a unit on heat. This question pushes students who have studied heat transfer, but have not explicitly learned about thermal expansion, to relate their observations of heat to a new situation.

When released items chosen for evidence circles are novel, small groups will be more likely to select a range of answers. A discrepancy in answers leads to richer whole-class discussion and pushes students to justify the evidence they used to support their answer. Evidence circles allow for a meaningful review of science content as well as the opportunity to build students' proficiency in the science practice of Engaging in Argument from Evidence.

Conclusion

Instead of viewing standardized test items as antithetical to the inquiry-oriented classroom or as summative assessments never to be seen again, these questions can be used to affect your students' conceptual understanding of science and science process skills. Integrating released items into your science lessons

FIGURE 6 Evidence-circle question (IEA 2013)



Which of the following best explains why some railroad tracks are laid down with gaps between the metal rail spans?

a. To allow for the metal tracks to expand on hot days

b. To allow for the metal tracks to expand on cold days

c. To allow for the cooling of the tracks by air in the gaps

d. To allow for vibration of the tracks due to the train

allows you to formatively assess your students and to create opportunities for meaningful classroom discussions. Further, when you use released items that align with the science practices outlined in the *Framework* and *NGSS,* you are preparing your students to be successful with the content and skills in the *Next Generation Science Standards*, both before and after they are adopted by your state. In addition, we believe that the strategies presented in this article will transfer to the assessments eventually developed for the *NGSS*. As teachers prepare for these future reforms in science education, standardized test questions are an unexpectedly valuable resource that can be used throughout the school year. ■

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Resources

AAAS science assessment—*http://assessment.aaas.org*

Explore NAEP questions—*http://nces.ed.gov/nationsreportcard/itmrlsx*

MOSART test inventory and development—*www.cfa.harvard.edu/smgphp/mosart/testinventory_2.html*

TIMSS & PIRLS—*www.timss.org*

Dina Drits-Esser (*Dina.Drits@utah.edu*) is the research and evaluation leader at the Genetic Science Learning Center at the University of Utah in Salt Lake City, Utah. ***Megan Black*** (*msblack@graniteschools.org*) is a science specialist at Granite School District and a middle school science teacher at Weilenmann School of Discovery in Salt Lake City, Utah.