CREATING ASSESSMENTS SUPPORT
Creating assessments that test the appropriate science practices taught and modeled in your inquiry-based classroom can be a challenge. Designing and delivering instructional experiences and assessments that incorporate higher-level thinking skills fosters student achievement and empowers students to be strategic in their thinking and planning. Teachers are charged with the task of developing students’ understandings about scientific inquiry and the nature of science. Learning to identify the different levels of thinking and keeping them in mind when designing appropriate student assessments will help budding scientists develop scientific habits of mind. Guskey (2003) reported that teachers often use test items from textbooks or instructional resources or attempt to create

FIGURE 1  Bloom’s revised cognitive taxonomy

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remembering</td>
<td>Retrieving, recognizing, and recalling relevant knowledge from long-term memory</td>
</tr>
<tr>
<td>Understanding</td>
<td>Constructing meaning from oral, written, and graphic messages through interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining</td>
</tr>
<tr>
<td>Applying</td>
<td>Carrying out or using a procedure through executing or implementing</td>
</tr>
<tr>
<td>Analyzing</td>
<td>Breaking material into constituent parts, determining how the parts relate to one another and to an overall structure or purpose through differentiating, organizing, and attributing</td>
</tr>
<tr>
<td>Evaluating</td>
<td>Making judgments based on criteria and standards through checking and critiquing</td>
</tr>
<tr>
<td>Creating</td>
<td>Putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning, or producing</td>
</tr>
</tbody>
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(Anderson and Krathwohl 2001)
Content standard C: Life science
As a result of their activities in grades 5–8, all students should develop understanding of the following:

- **Population and ecosystems**
  Populations of organisms can be categorized by the function they serve in an ecosystem. Plants and some microorganisms are producers—they make their own food. All animals, including humans, are consumers that obtain food by eating other organisms. Decomposers, primarily bacteria and fungi, are consumers that use waste materials and dead organisms for food. Food webs identify the relationships among producers, consumers, and decomposers in an ecosystem.

- **Diversity and adaptations of organisms**
  Biological evolution accounts for the diversity of species developed through gradual processes over many generations. Species acquire many of their unique characteristics through biological adaptation, which involves the selection of naturally occurring variations in populations. Biological adaptations include changes in structures, behaviors, or physiology that enhance survival and reproductive success in a particular environment.

### Assessment questions that incorporate graphics

**Multiple-choice example: Remembering level**

The following picture represents which type of organism?

- a. Herbivore
- b. Decomposer
- c. Carnivore
- d. Producer

**Multiple-choice example: Analyzing level**

Based on the information you can observe in the picture below, what type of consumer is the following animal?

- a. Herbivore
- b. Omnivore
- c. Carnivore
- d. Decomposer

**Constructed-response example: Evaluating level**

Examine the food-web graphic below.

a. Explain how a large decrease in the availability of producers in this food web will most likely affect the consumers represented in the diagram.

b. Describe the possible effects of a large decrease in producers on the decomposers represented in this food web.
## Assessment questions that incorporate scenarios

**Multiple-choice example**: Remembering level  
A field scientist is currently identifying and cataloging all of the decomposers found in a local wilderness area. A decomposer's main role in an ecosystem is to:  
- a. Recycle nutrients in the ecosystem  
- b. Reflect heat from the forest floor  
- c. Provide habitat for organisms  
- d. All of the above  

**Multiple-choice example**: Analyzing level  
Scientists have discovered a new animal in South America. This large, bear-like animal enjoys running through the jungle and swimming in rivers. This animal eats stems, plant leaves, and even fish. Based on the evidence that the researchers found, as what type of consumer should this animal be classified?  
- a. Herbivore  
- b. Carnivore  
- c. Omnivore  
- d. Decomposer  

**Constructed-response example**: Evaluating level  
Long ago, there were many kinds of dinosaurs that roamed the Earth. There were some dinosaurs that ate only meat, some that ate only plants, and some that ate both. At a recent scientific expedition, scientists uncovered a frozen dinosaur. The following is a list of observations of the scientists:  
- The dinosaur's stomach contained evidence of both animal and plant materials.  
- The dinosaur's skin was rough and scaly.  
- The dinosaur's jaws included sharp teeth in the front and wide flat teeth in the back.  

a. Draw inferences of what type of consumer this dinosaur was.  

b. Provide pieces of evidence to support your inferences.

## Assessment questions that incorporate quotes

**Multiple-choice example**: Remembering level  
Quote: “It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is the most adaptable to change.” —Charles Darwin  
Read the above quote: Which answer best represents the definition of *adaptable*?  
- a. The ability to successfully respond to environmental changes  
- b. The ability to reproduce  
- c. The ability to migrate  
- d. The ability to escape from predators  

**Multiple-choice example**: Analyzing level  
Quote: “It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is the most adaptable to change.” —Charles Darwin  
Read the above quote. What is Darwin referring to when he states that the strongest of the species is the one that is most adaptable to change?  
- a. Genetic variation  
- b. Extinction  
- c. Naturalism  
- d. Evolution  

**Constructed-response example**: Analyzing level  
Quote: “It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is the most adaptable to change.” —Charles Darwin  
a. Explain whether you agree or disagree with Darwin's quote.  
b. Provide two examples to support your position.
Creating Science Assessments that Support Inquiry

their own classroom assessments. While the use of readily available resources to create assessments is a good first step in planning, it is important for teachers to ascertain that their assessment items crafted for learning entail higher-order thinking skills. In many instances, assessment items require recall of information and not the higher-level process skills that teachers try to inculcate in their students. For higher-order thinking to occur in assessment, students must use thinking skills that require reflection, presentation of logical arguments, and the ability to draw conclusions.

A variety of resources are available for teachers to apply higher-level thinking and cognitive complexity to their instruction and assessments. In the 1950s, Benjamin Bloom designed a taxonomy for categorizing mental thought processes in graduated levels of complexity. Lorin Anderson and David Krathwohl (2001) updated the taxonomy to add relevance for the 21st century. Figure 1 provides a graphic representation of Bloom’s revised cognitive taxonomy.

**Importance of higher-level thinking**

Teachers must simulate those higher-level thinking experiences in their activities and assessments. Numerous research studies document that when teachers improve classroom assessments, it can have a positive impact on student achievement (Black and William 1998).

Practicing process- and skill-based questions not only prepares students for standardized assessments, it also helps develop their critical-thinking skills. More importantly, this type of practice helps students develop fluency with scientific practices such as analysis, interpretation of data, and construction of explanations for drawing conclusions based on data. Treffinger (2008) commented, “Teachers can help students become 21st century problem solvers by introducing them to a broad range of thinking tools.”

To achieve depth of understanding with new content takes time; thus, content to be studied must be prioritized. Science teachers are well aware that when students have a shallow understanding of concepts, the content is typically not remembered. Benjamin Bloom (1956) commented that “teachers frequently say: ‘If a student really comprehends something, he can apply it’” (p. 120). Understanding gives deep meaning, establishes significance, and draws connections. Enhancing students’ problem-solving skills is necessary for their ability to confront real-world challenges in their future careers. When students possess acquired knowledge that cannot be applied, that knowledge remains inert. True problem-solving skills involve the ability to apply acquired knowledge to macro-contexts that can be used in novel settings.

**Developing items**

Llewellyn (2002) stated that “assessments are defined as evaluation strategies that are unconventional, student-centered, meaningful, interesting, and relevant to the learner.” When a student must reframe content learned in a novel situation, such as a quote, graphic, or scenario, and apply that knowledge in an appropriate context, the learner is required to employ critical-thinking skills toward the task. To create an assessment item, first select the standard that will be assessed. These standards should be the basis of the teacher’s instructional activities and also align with the assessments. Many argue that this is “teaching to the test.” However, it seems only right and fair to design learning experiences that match with standards and assessments. For the examples in Figure 2, a set of formulated assessment questions aligned with a science content standard is presented. An example of a lower cognitive complexity “remembering”-level question is presented, and then two examples are provided at higher cognitive levels using graphics, quotes, or scenarios to boost the complexity of the questions.

**Graphics**

There are a variety of graphics that teachers can use to design high-cognitive-level assessments, including illustrations, paintings, charts, graphs, and maps. In addition, science websites can be another rich source of graphics. Charts and data are effective to assess students’ ability to scrutinize text and data and draw conclusions. Figure 2 provides examples of multiple-choice questions that assess students’ understanding of science graphics at various levels of cognitive complexity. The sample questions include graphics for students to examine and select the answer that best describes the information presented in the graph. To promote still greater levels of higher-order thinking, a constructed-response assessment is shown based on this same content standard.

**Scenarios**

Another way to create higher-level test questions is to develop scenarios. Scenarios are hypothetical situations requiring students to glean the key facts from
the situation and draw connections to the topics being studied, thus creating new applications of knowledge. Using typical real-world situations, students can use their problem-solving skills by analyzing situations presented in scenarios.

Quotes
Another strategy for incorporating scientific practice skills in assessments is using quotes. When students are required to make inferences and draw conclusions about a quote, higher-level cognitive abilities are employed to decipher its meaning. Fortunately for science teachers, there are many quotes available. Teachers can find quotes in their textbooks as well as on the internet. By using student comments or answers on their assignments as quotes, teachers can highlight common misconceptions. Teachers can also use quotes from local scientists, school administrators and faculty, or community members to engage students in evaluating information and scientific discourse. When selecting quotes, it is important to consider students’ reading abilities. Students need to understand the quote, so they can select the correct answer.

Conclusion
While designing higher-level assessments might be a challenging task, doing so not only can improve student achievement in science, it also prepares students for a changing world. Students learn to become independent thinkers and problem solvers, enabling them to adapt and succeed in an evolving workplace. Graphics, scenarios, and quotes are tools to help science teachers conquer the challenge of creating higher-level assessments that incorporate the use of science process skills. Generating effective assessments in science is paramount for assisting students in developing scientific habits of mind and understanding about the nature of science.

References

Resources
American Association for the Advancement of Science assessment items and resources—http://assessment.aas.org/topics
National Assessment of Educational Progress sample questions booklets—http://nces.ed.gov/nationsreportcard/about/booklets.asp
Quick flip questions for the revised Bloom’s taxonomy—www.american-classroom-supply.com/ep-729.html
Revised Bloom’s taxonomy—www.edu.edu/educ/roverbau/Bloom/blooms_taxonomy.htm
Teacher resources of revised Bloom’s taxonomy—www.niu.edu/facdev/programs/handouts/blooms.shtml

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