Formative Assessment of English Language Proficiency in the Science Classroom

By Okhee Lee and Rita Januszyk

In a linguistically diverse fourth-grade classroom, students carry out an investigation to answer the lesson question: How are we able to see objects? Working collaboratively in groups, students are given a lidded box with an eye hole and a flap. Students make predictions about the contents of the box and then develop models using drawings, symbols, and text. What’s inside the dark box? It’s a mysterious beginning to the lesson.

According to the vision of the Next Generation Science Standards (NGSS), science and engineering are language intensive and offer both opportunities and challenges for all students, especially English learners (ELs), who are developing language and disciplinary knowledge and practices simultaneously (Lee, Quinn, and Valdés 2013). As students engage in three-dimensional learning to make sense of phenomena and build their science understanding over time, they grow in their ability to use language and other meaning-making resources such as symbols.

To support ELs of varying levels of English proficiency, the teacher must gather information about student learning that can be used to advance students’ language proficiency in science. Formative assessment can be a powerful means for gathering such information and using it to provide ongoing and contingent support. This article focuses on formative assessment of language proficiency (shortened to “proficiency” hereafter) in the context of NGSS-aligned science instruction.

FRAMEWORK FOR LANGUAGE USE IN THE SCIENCE CLASSROOM

Formative assessments must begin with a clear picture of what language is used in the science classroom and how students progress across proficiency levels. Our framework focuses on two key aspects of language use in the science classroom: modalities and registers.

Modalities refer to the multiple and diverse channels through which communication occurs (e.g., talk, text, graphs, charts, symbols, equations). Whereas traditional notions of “academic language” tend to focus exclusively on linguistic modalities (i.e., talk and text), our framework expands the definition of language to include nonlinguistic modalities (e.g., symbols), which are essential meaning-making resources of the science disciplines (Lemke 2002).

Registers are varieties of language associated with particular contexts of use (Biber and Conrad 2009). While a colloquial register is common in everyday communications, as in a conversation with a friend (talk) or a text message (text), a specialized register is a precise and explicit form of communication, as in an oral report to the class (talk) or an article on a topic (text). Unlike traditional notions of “academic language” (defined in terms of vocabulary and grammar), a register perspective views language as a product of, rather than a prerequisite to, science learning.

Table 1 illustrates how ELs use modalities and registers across proficiency levels. As students develop a more expansive repertoire of modalities, they will use increasingly strate-

<table>
<thead>
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<th>TABLE 1</th>
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<td>Students’ use of modalities and registers across proficiency levels.</td>
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<tr>
<td>Level 1</td>
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<tr>
<td>Modalities</td>
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<tr>
<td>Registers</td>
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logic ways to communicate their ideas. Students also grow in their ability to use a more specialized register to precisely communicate their ideas.

LIGHTBOX INVESTIGATION TASK

Based on our framework for language use in the science classroom, we articulate a set of language proficiency descriptors aligned to an NGSS task. The relevant NGSS performance expectation (PE) in physical science for fourth grade incorporates a science and engineering practice (SEP; “develop a model”), disciplinary core idea (DCI; “that light reflecting from objects and entering the eye”), and crosscutting concept (CCC cause and effect; “light . . . allows objects to be seen”). See Connecting to the NGSS, p. 85, for more information. The lightbox investigation task is based on a similar task for middle school science in the Investigating and Questioning our World through Science and Technology (IQWST) curriculum units (see Internet Resources).

Students in small groups were given a box with two holes (a light hole covered by a flap and an eye hole) and a toy turtle inside (Figure 1; see Internet Resources for a pre-made light box, and see NSTA Connection for directions posted online). Students made observations of the turtle under several conditions (i.e., flap closed, flap open, and flashlight shining through the flap). Viewing the contents of the box under different conditions allowed students to understand that light causes an object to be seen (CCC) when it reflects off the object and enters the eye (DCI).

After developing initial models of how they could see the toy turtle in the box, students revised their models by engaging in related investigations until they individually produced their final models (SEP).

Table 2 articulates language proficiency descriptors for assessing students’ final lightbox models. As indicated at the top of the table, students at all proficiency levels are expected to meet the targeted PE. Thus, the descriptors reflect the NGSS vision of “all standards, all students.” However, because ELs are still developing the language necessary to access grade-level instruction in English, they typically use language with varying degrees of proficiency. Across proficiency levels, students make increasingly strategic use of modalities and more precise and explicit use of registers.

LIGHTBOX MODEL EXAMPLES

We present four lightbox models corresponding to the four proficiency levels articulated in the descriptors in Table 2. The models offer examples of how language is used at each proficiency level and the progression of

| TABLE 2 |

Proficiency descriptors for assessing lightbox investigation models.

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<thead>
<tr>
<th></th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
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<tbody>
<tr>
<td><strong>Modalities</strong></td>
<td>Using drawings, symbols, and limited text</td>
<td>Using drawings, symbols, and some text</td>
<td>Using a strategic combination of drawings, symbols, and extensive text</td>
<td>Using a strategic combination of drawings, symbols, and extensive text</td>
</tr>
<tr>
<td><strong>Registers</strong></td>
<td>Using words and memorized chunks of text</td>
<td>Using words and familiar patterns of text</td>
<td>Using colloquial terminology and text</td>
<td>Using disciplinary terminology and text</td>
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Students at all proficiency levels meet the performance expectation (4-PS4-2) by...
language use across the four proficiency levels.

Figure 2 depicts a lightbox model at Level 1 proficiency. The model includes all of the features from the investigation, including the object (turtle), eye, light, and open view (open flap). The student drew arrows, which are key meaning-making resources in science disciplines (Kress 2000), to show the relationships among the features. Specifically, the arrow in Figure 2 shows the path of light as it originates from the flashlight, passes through the open flap, reflects off the turtle, and enters the eye. The scientific principle of reflection is communicated by the direction of the arrow, which reflects off the turtle and points toward the eye. (A common misconception is to draw an arrow from the eye pointing toward the turtle.) The arrow thus sets up a causal relationship between the light reflecting off the turtle and the eye’s ability to see the turtle. While the model is replete with meaning due to the use of multiple modalities, the student’s use of text (i.e., written language) is limited to a small number of labels (“Light” and “Reflection”) and a short title in the form of a memorized language chunk (“Turtle in a Box”).

Figure 3 depicts a lightbox model at Level 2 proficiency. Similar to the Level 1 model, this model uses multiple modalities to communicate the scientific principle of reflection and to explain the causal relationship. This model goes beyond the previous model because it contains multiple arrows emanating from the turtle to represent how light reflects off an object in multiple directions, not just to the eye. In comparison with the Level 1 model, this model provides more labels for features and also includes a simple sentence using a familiar language pattern (“Lid is off”) to clarify the condition of the investigation represented in the model. This combination of text with drawings and symbols makes the model more explicit, thus increasing the likelihood of it being understood by someone unfamiliar with the investigation. Still, the model relies heavily on drawings and symbols to convey its intended
meaning, leaving substantial room for misinterpretation.

Figure 4 shows a lightbox model at Level 3 proficiency. It contains many of the same elements from the previous two models plus substantially more text. By strategically combining extensive text with drawings and symbols, Figure 4 is more precise and explicit than either model. Specifically, the use of text guides the reader through the causal sequence of events represented by the drawings and symbols. The student uses an everyday register (“bounces off”) to describe the science idea of reflection and a coordinating conjunction (“so”) to explain the causal relationship. Still, the terminology (“bounces off”) is imprecise, and the text (“so when a person looks in the box they can see Tuck [the toy turtle]”) does not make explicit that light enters the eye. Thus, there is still room for improvement in the precision and explicitness of register.

Figure 5 depicts a lightbox model at Level 4 proficiency. Of the four models, this one demonstrates the most strategic use of multiple modalities and the most precise and explicit use of register. In addition to representing the features and their relationships, this model uses drawings strategically to represent the shadow behind the turtle resulting from the turtle’s obstruction of light. As in the Level 3 model, Figure 5 also uses a coordinating conjunction (“so”) to explain the causal relationship. However, unlike the Level 3 model, the use of disciplinary terminology (“reflects”) achieves the precision needed to communicate scientific ideas, and the text makes explicit that light entering the eye causes the turtle to be seen (“into our eye so we can see”). Notably, this model is more concise than the Level 3 model. Although a certain amount of language is needed for effective communication, wordy sentences can be counterproductive. Because less is sometimes more when communicating scientific ideas, teachers should attend to the quality, rather than quantity, of their students’ texts.

**Figure 4**
Lightbox model at Level 3 proficiency.

**Figure 5**
Lightbox model at Level 4 proficiency.
CLASSROOM RECOMMENDATIONS

Across the four lightbox models, students make increasingly strategic use of multiple modalities and more precise and explicit use of register, which enables them to more effectively communicate their ideas. The descriptors provided in Table 2 can be a useful tool for formatively assessing students’ models at multiple points over the course of instruction (e.g., initial, revised, and final models). What makes assessment truly formative, however, is that teachers and their students use assessment information to guide teaching and learning going forward. We offer the following three recommendations for using formative assessment to promote language proficiency.

1. Engage students in conversation about their models.
   Ask probing questions that guide students toward more strategic use of multiple modalities and more precise and explicit use of register (e.g., What does this arrow mean? Is there a more precise way of saying “bounces off”?).

2. Provide scaffolds for students’ use of text (i.e., written language).
   For example, ask students to number the relationships represented by their drawings and symbols (e.g., use 1, 2, 3 to indicate the sequence of events). Then, ask students to write what is happening at each time point in the model.

3. Create opportunities for students to assess their own and each other’s models.
   For self-assessment and peer-assessment to be effective, students must have a clear idea of what a “good” model looks like (Harris et al. 2016). One way to do this is to co-construct a set of criteria with the class. Once these criteria are established, set up a “gallery walk” in which students use sticky notes to write respectful comments and questions on each other’s models. Then, students revise their models based on feedback from their peers.

These recommendations are useful for promoting language proficiency and science learning. All four lightbox models show evidence of meeting the NGSS PE, although they vary considerably in terms of language use. Of course, this may not always be the case, since at any given time, students will be at varying points in both their language proficiency and science learning. Formative assessment, then, can be a powerful tool for advancing students’ language proficiency and science learning in tandem and for guiding instruction with all students, especially ELs.

REFERENCES

INTERNET RESOURCES
Activate Learning
http://activatelearning.com/iqkwst/
Light Box, Pre-cut
www.activatelearningstore.com/product.aspx?item=C01652&name=Light+box%2c+Pre-Cut&groupid=9271

NSTA Connection
Download instructions for making a light box at www.nsta.org/SC0719.

Read NSTA’s free online journal, Connected Science Learning
CSL explores programs codeveloped by schools and out-of-school organizations, including museums, science centers, afterschool providers, zoos, and aquaria. If you’re involved in program development or want to start STEM partnerships in your community, this is the journal for you. You can view the articles and subscribe at http://csl.nsta.org.
Connecting to the Next Generation Science Standards (NGSS Lead States 2013)

Standard
4-PS4 Waves and Their Applications in Technologies for Information Transfer www.nextgenscience.org/pe/4-ps4-2-waves-and-their-applications-technologies-information-transfer

- The chart below makes one set of connections between the instruction outlined in this article and the NGSS. Other valid connections are likely; however, space restrictions prevent us from listing all possibilities.
- The materials, lessons, and activities outlined in the article are just one step toward reaching the performance expectation listed below.

Performance Expectation
4-PS4-2: Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.

<table>
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<tr>
<th>DIMENSIONS</th>
<th>CLASSROOM CONNECTIONS</th>
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<tr>
<td>Science and Engineering Practice</td>
<td>Students develop a lightbox model with features (object, eye, light source, and open view) and their relationships (light originating from the light source, reflecting off the object, and entering the eye).</td>
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<tr>
<td>Disciplinary Core Idea</td>
<td>Students understand that light is reflected from the surface of an object. The ability to see the object occurs because the reflected light enters the eye.</td>
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<tr>
<td>Crosscutting Concept</td>
<td>Students identify the relationship between light and the ability to see an object. The cause is light entering the eye, and the effect is being able to see the object.</td>
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Connecting to the Common Core State Standards (NGAC and CCSSO 2010)

ELA/Literacy

**SL.4.1** Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 4 topics and texts, building on others’ ideas and expressing their own clearly.

Students engage in discussions while investigating and developing a model.

**W.4.2.** Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

Students convey ideas in writing to answer the investigation question.

Okhee Lee (olee@nyu.edu) is a professor at New York University in New York City. Rita Januszyk is a retired elementary teacher from Hinsdale, Illinois.