Literacy Focused Science Instruction for ELLs

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Apples

- Imagine that you have never seen an apple.
- What would help you understand the concept of an apple?
- Turn and talk to your neighbor.
- Keep your responses in mind as we go through an apple observation.
**Apple Observation Recording Sheet**

Get out a piece of paper.  
Fold it in half.  Fold it in half again.

<table>
<thead>
<tr>
<th>Picture of apple</th>
<th>Model of apple</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Real apple</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>
Apple Observation

• Using the picture of the apple, make as many observations of the apple as you can. Add to your recording sheet.
• Remember that you cannot touch, smell, or taste the apple.
Apple Observation using a Model

• Observe the model of an apple.

• Add your observations to your record sheet.

• Note: You can touch it but you still cannot smell or taste it.
Apple Observation with Real Apple

- Holding the apple, make as many observations of the apple as you can.
- Add to your recording sheet.
- Remember now you CAN touch, smell, and taste and hear the apple (*hear the sound of eating the apple*)
Discussion of Apple Activity

- Why are real world, concrete experiences so important in the teaching and learning of science for English language learners?
- Take 5 minutes to turn and discuss with a different person than your neighbor.
- Add your discussion points to the last box on your Apple Recording Sheet.
Language Development Needs:

- Multiple opportunities to hear and use language
- Rich contexts and the opportunity to engage and contribute
- Appropriate supports
- Acceptance of “flawed” language
Science Understanding Needs:

- Multiple opportunities to hear and use science ideas
- Rich contexts and the opportunity to engage and contribute
- Appropriate supports
- Acceptance of “flawed” language for example non-scientific language
Promoting Both Science and Language Learning for ELLs

- ELLs can participate in classroom discourse focused on rich experiences and exciting academic content.

- ELLs learn language best when academic content is integrated with engaging, rich experiences.

- ELLs can have opportunities for extended engagement with complex ideas when focusing on both text and discourse.
Inquiry Question: How are wool and burlap the same and how are they different?

Set up a Box T Chart.

<table>
<thead>
<tr>
<th>Same</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wool</th>
<th>Burlap</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Wool v. Burlap

- Inquiry Question: How are wool and burlap the same and how are they different?
- Get into groups of four.
- Materials to share
  - Two hand lens
  - One piece of wool
  - One piece of burlap
- Take 5 minutes to discuss and then record your observations in your Box T Chart
Inquiry Question: How are wool and burlap the same and how are they different?

Responses from a 6\textsuperscript{th} grade ELL classroom

<table>
<thead>
<tr>
<th>Same</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cloth</td>
</tr>
<tr>
<td>Woven</td>
</tr>
<tr>
<td>Stretches</td>
</tr>
<tr>
<td>Both came from living organism</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wool</th>
<th>Burlap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal</td>
<td>Hemp plant</td>
</tr>
<tr>
<td>Different colors</td>
<td>Rough</td>
</tr>
<tr>
<td>Soft</td>
<td>Strong odor</td>
</tr>
<tr>
<td>No smell</td>
<td>Large weaving on holes</td>
</tr>
<tr>
<td>Pattern caused by different colored thread</td>
<td>Neutral color</td>
</tr>
<tr>
<td></td>
<td>itchy</td>
</tr>
</tbody>
</table>
Next Step: Compare and Contrast
Whole class dictation to teacher.

The burlap and the wool are the same because they are both made of cloth and come from nature or living things. In addition, the burlap and the wool both have little squares for their shape and they are bendable and stretchable on the bias.

They are both different because the burlap has a rough texture and the wool has a soft texture. Also, the burlap is a natural color and the wool has dyed threads. Finally, the burlap comes from a plant the the wool comes from an animal, the sheep.
Writing Frame

The _______ and the ___________ are the same because they both _____________________________. In addition, they _________________________________.

They are different because the ________________, and the ________________. Also, _________________. Finally

_______________________________.

Find my Shell!

- In this scientific observation, students
  - practice measuring and recording data by observing a shell
  - share notes and observations with other classmates to practice their descriptive note taking skills
  - use observation data to write a descriptive paragraph of the shell
Find my Shell

- Get into groups of 8.
- Each group should have a blue container with a bag of shells.
- Each person should select one shell from the bag.
- Take 5 minutes and individually, get to know your shell.
  - Record as much information as you can about your shell: shape, color, markings, pattern, measurements, etc.
  - Be as accurate as you can.
Find my Shell

- Return your shell to the blue container.
- Mix up the shells.
- Now try to locate your shell.
- Next, put the shells back in the blue container and trade notes with a partner.
- Partners try to locate the shell based on the notes.
Find my Shell
Writing Descriptive Paragraphs

- Ask students to create a rubric with indicators of what a descriptive paragraph should contain.
- Then, direct students to write a descriptive paragraph introducing their shell.
- Next, trade paragraphs and see if the shells can be found based on the descriptions.
- Finally, ask students to use the rubric to analyze the descriptive paragraphs.
  ◦ What worked? What could be improved?
Building Science Content for ELLs

- Activate prior knowledge through inquiry
- Provide hands-on/minds-on experiences
- Promote scientific genres of writing
- Connect science process skills (e.g., describe, explain, predict, conclude, report) to language functions (e.g., explain, compare, contrast)
- Encourage use of graphic organizers (e.g., concept map, word wall, Venn diagram, KWL)
Home Culture Connections

• Build on students’ lived experiences at home and in the community (i.e., funds of knowledge)

• Explore culturally-based ways students communicate and interact in their home and community (i.e., cultural congruence)

• Use students’ cultural artifacts, culturally relevant examples, and community resources
Imagine two fourth-grade classes. Both contain students of comparable demographics and highly respected teachers each with four to five years of experience. Both classes engage in science curricula that emphasize science and engineering practices as outlined in the Next Generation Science Standards (NGSS Lead States 2013). Both classes earn similar scores on tests that assess acquisition of science content knowledge. Yet, despite these likenesses, at the year’s end, all of the students from one class view themselves to have some characteristics of a “smart science student” while only half of the students from the other class do so. You are probably already wondering what teaching practices might account for the differing outcomes in these two imagined classrooms. Fortunately, we do not have to just imagine; a recent research study (Carlone, Haun-Frank, and Webb 2011) reports on this very situation and offers an accounting of the differing classroom practices and their impact on how students do or do not affiliate with the characteristics of being a “smart science student.”

Our research team observed and videotaped about 60 lessons (one animal adaptation unit and one electricity/magnetism unit) in the two classrooms. Class A was a dual-language, bilingual classroom in a Title 1 school; the class population was 32% White, 58% Latino, and 10% African American. Class B was also in a Title 1 school and the class population was 58% White, 21% Latino, 17% African American, and 4% biracial. In this article, we translate the results of the research report for teachers so that they can gain insights into the types of classroom practices that not only help students construct science content knowledge and acquire inquiry skills, but also enable more students to affiliate themselves with the idea of being a “science person.” To do so, we first present brief vignettes of sample practices that were representative of the small-group work and whole-class discussions that occurred in the two classrooms. Both vignettes illustrate students’ work in small groups during a magnetism and electricity unit, focused on the NGSS: Disciplinary core ideas PS3.A (Definitions of energy), PS3.B (Conservation of energy and energy transfer), and PS2.B (Types of interactions); crosscutting concept Energy and Matter; and multiple science and engineering practices. We ask the reader to reflect on these two vignettes and decide which practices, enacted over time with other curricular topics, would most likely lead to the research findings mentioned earlier. Finally, after revealing which classroom is which, we unpack the teaching practices and present specific strategies to illustrate how each supports or constrains students in affiliating with being a science person.
Vignette 1: Sample Practices in Mrs. Sparrow’s Class
Sharing Materials by Taking Turns

Near the beginning of a unit on electricity and magnetism, Mrs. Sparrow has her students work in small groups to light a bulb on a circuit board (i.e., a battery holder, a bulb holder, clips, wires, battery, and a bulb). Each group crowds around its materials at a table, and students energetically take turns trying out different combinations. They are polite and generally respectful with one another as they share materials and take turns. For example, in one group, three students take turns fiddling with the circuit board:

Caitlin: Guys, can I try something?
Neil: Hey. Let me try an idea.
Caitlin: Can I try something real quick?
Max: Sure.
(Caitlin disconnects and reconnects wires.)
Max: I got an idea.
Neil: After Caitlin is my idea, Max.
Max: Okay, but then my idea.
Caitlin: This one doesn’t light at all.
Neil: Okay, my turn. I’m assuming that there’s a wire, that this wire is connected here and we may as well see if there is—
Max: I’ll just test.

Helping Students Identify the Main Concept

Later in the unit, Mrs. Sparrow leads a whole-class discussion on what the students found in a recent inquiry where they examined the relationship between the force exerted by a magnet on a magnetic object and the distance from which the object is placed from the magnet. As shown in the following dialogue, Mrs. Sparrow guides students toward identifying the main concept to be learned from the inquiry:

Colin: [We were supposed] to figure out how many spacers you could put in and how many washers you could put in to see how strong the magnets are.
Mrs. Sparrow: Ok.
Colin: We were trying to see how strong the magnets were attracted together.
Mrs. Sparrow: Ok.
Colin: The more spacers, the less washers.
Mrs. Sparrow: Let’s stick to the more space between the magnets, the—?
Colin: Less attractions!
(Mrs. Sparrow looks to the next student with hand raised.)
Forrest: When there’s more space, the weaker the magnet. It’s not as powerful.
Mrs. Sparrow: Well not the magnet, but the—?
Forrest: Force!
Mrs. Sparrow: So the more space between the magnets, the weaker the—?
Forrest: Force.
Mrs. Sparrow: Very good. We will continue talking about magnets next week.

Vignette 2: Sample Practices in Ms. Wolfe’s Class
Sharing Ideas and Explanations

As in Mrs. Sparrow’s class, Ms. Wolfe has her students work in pairs or small groups on the same challenge of lighting a bulb. Several days later, after discussing all the ways that the students found to light the bulb, Ms. Wolfe prompts the students to think about how the incorporation of new components (e.g., switches, additional batteries, length of wires, and so on) might impact the circuit’s functioning. The class then decides to test these new components. As the students cluster around their materials and complete their tests, they share ideas with each other (and sometimes with other groups) and offer explanations to justify their ideas. For example, a pair of students constructs a circuit with a switch and are surprised by the bulb’s brightness when they close the switch:

Alejandro: Oh my that [light] is so bright.
Alejandro: (to someone else in a nearby group) Look! Ours is really bright.
Student: (from another group) It’s not as bright as ours.
Jeremy: Look at this—it’s got a switch though.
Alejandro: (to Jeremy) But how could we make it brighter?
Jeremy: With more batteries.
Alejandro: Explain.
Jeremy: More batteries, less wire.
Student: (from the other group) Why do you want to use less wires?

Jeremy: Because the wires just make a longer place for the electricity to go and then that means that the electricity travels more and doesn’t have as much strength.

Generating New Investigations

After students complete one investigation, Ms. Wolfe encourages students to share what they have found with the rest of the class and to discuss how their findings compare with others. During these whole-class discussions, Ms. Wolfe also grapples with the students’ ideas and uses them to generate new investigations. For example, in the following excerpt, the students discuss what they found when they were testing how many magnets were needed to induce magnetism to form a paper clip chain for a specific number of paper clips:

Sanchez: We also noticed that it was not possible (to form a paper clip chain) with just one or two magnets.

Ms. Wolfe: Hmm.

Sanchez: It was only possible with three magnets.

Ms. Wolfe: That is interesting. What would you add, Christine?

Christine: Well, I kind of disagree with Sanchez, because me and Ramón got six magnets to do that.

(About five minutes later in the discussion, Jeremy picks up this thread).

Jeremy: May I say something that I really [want to share]?

Ms. Wolfe: Yes.

Jeremy: Like Christine was saying that you could get it (form a paper clip chain) with what Sanchez said of magnets (3 magnets), I got it with less. I got it with one and two magnets.

Ms. Wolfe: You mean when [the magnet] was vertical? Okay. That’s a whole other interesting entity. Interesting. You did? Amy, I haven’t heard from you.

Amy: I disagree with Sanchez. Because we only used one and two magnets and we got about the same thing. There was only like a two or three difference (in number of paper clips in the paper clip chain).

Ms. Wolfe: Okay. Well Sanchez’s definitely found a pattern that he was able to prove. Now, something that you did could have been slightly different from what he did. But he was onto something, and I thought that was interesting.

(The next day’s investigation centered on testing Sanchez’s idea with a consistent protocol across groups, created in a class discussion.)

Now that you have read brief descriptions of sample practices in Mrs. Sparrow’s and Ms. Wolfe’s classes, take a few minutes to reflect on any distinctions between the two and then decide which class produced more students who affiliated with characteristics of a “smart science student.” Once you have completed this reflection, look at the next page to find out which class connects to which outcome (see Table 1).
tricable connections between their practices and the implicit meanings of “being scientific” and “doing science” that accompany those practices.

**Strategy 1**

*Ms. Wolfe made explicit and accessible what it meant to be scientific.*

Before beginning any investigation, she held a class discussion so that students had a say in defining what counts as “good scientific work.” She helped students realize that science practices such as those outlined in the NGSS (e.g., asking questions, planning and carrying out investigations, engaging in argument from evidence) may look different depending on the activity. Nearly every investigation demanded a new conversation about expectations for “good scientific work.” Students clearly understood what was expected for quality work and, because they had a voice in defining those criteria, felt capable of meeting expectations.

**Example:** Before embarking upon their investigation of fiddler crabs, Ms. Wolfe asked students to jointly contribute to a conversation about what will count as a “detailed observation” of and a “good question” about their habitats. These ideas were then used to set the criteria for the students’ drawings, observations, and questions in their science notebooks.

**Strategy 2**

*Ms. Wolfe held every child accountable for expressing scientific thinking.*

She set the expectation that all students verbally share their observations, inferences, explanations, and questions during group work and whole-class discussions. To do so, she used generative questions that began with “why,” “what if,” or “how else.” She requested that all students provide justification and evidence for their reasoning before they proceeded to the next investigative step. She encouraged students to both listen to one another’s ideas and ask each other questions in a friendly, respectful tone. By doing so, she sent the message that no student is excluded from engaging in scientific practices—i.e., asking questions, constructing scientific explanations from evidence, and communicating their scientific ideas. Further, this strategy signaled that every student’s contribution was important and valued.

**Example:** Ms. Wolfe stated, “I’m gonna pick the least talkative person who probably has not stood up for themselves and say, ‘The group can’t start until this person tells me what the plan is. All people in a group are responsible for being able to share out.’”

**Strategy 3**

*Ms. Wolfe reinforced and praised the diverse ways students performed scientifically.*

She acknowledged and celebrated many students’ ideas that helped the class construct a scientifically acceptable explanation for the results obtained during an investigation, explicitly drawing out different and relevant contributions students made. In her classroom, being scientific not only meant obtaining the right answer, but also included, for instance, thinking divergently, solving problems, asking questions, making unique observations, and thinking of new investigations. Finally, she provided time for students to compare and make sense of all the groups’ findings and then identify questions that could lead to new investigations.

<table>
<thead>
<tr>
<th>TABLE 1.</th>
<th>The percentage of students in each class that identified with some characteristics of “smart science students.”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identified self as sharing some characteristics with smart science students</td>
<td>Did not identify any characteristics shared with smart science students</td>
</tr>
<tr>
<td>Class A: Ms. Wolfe’s class</td>
<td>100%</td>
</tr>
<tr>
<td>Class B: Mrs. Sparrow’s class</td>
<td>54%</td>
</tr>
</tbody>
</table>
In Figure 1, we summarize students’ descriptions during end-of-year interviews of “smart science people.” There is a keen difference between the ways “smart science person” got defined in each classroom. Ms. Sparrow’s students defined a smart science person as someone who knows a lot of facts and can answer the teacher’s questions correctly, while Ms. Wolfe’s students focused on more generative practices like being good observers, thinkers, and question-askers.

We think the children’s definitions of “smart science kids,” coupled with the practices in Ms. Wolfe’s class described earlier, provide a good first step for teachers to reflect on the “we” cultures in their own classrooms (see NSTA Connection for the reflection checklist). By completing this checklist, we expect that teachers will be able to identify which strategies are currently present in their practice and then set goals for implementing those specific strategies that are not.

In Ms. Wolfe’s class, when asked to identify the three “smart-est” science people in their class, a few children responded, “We are all smart science people!” This is the ideal outcome—that all children consider themselves and their peers to be smart in science. A “we” culture can help facilitate that outcome. However, creating

**Shared Assumptions About Smart Science Students**

Creating a “we” culture begins with two underlying assumptions: (1) all children can be scientific and (2) children are scientific in different ways and therefore make unique, enriching contributions to the community’s collective scientific endeavors and knowledge.

![FIGURE 1.](image)

**FIGURE 1.**

A comparison of the total times students mentioned various characteristics when prompted to describe “smart science kids.”

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Sparrow’s Students</th>
<th>Wolfe’s Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is naturally smart / Knows facts</td>
<td>11</td>
<td>3</td>
</tr>
<tr>
<td>Answers teacher’s questions correctly</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Does science outside of school</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Is a good observer</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Is a good thinker</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>Asks questions / Is curious</td>
<td>3</td>
<td>10</td>
</tr>
</tbody>
</table>

Example: Ms. Wolfe encouraged careful observation by “valuing all the small pieces of things that people notice.” We saw this in the second discussion of Vignette 2 when Ms. Wolfe elicited a range of observations from students as they discussed the diverse results obtained in the initial investigation that explored how many magnets were needed to form a paper clip chain.
a “we” culture demands ongoing self-examination of our daily practices, the accessibility of those practices for all learners, and the implicit meanings of what counts as “being scientific” prompted by those practices.

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References

NSTA Connection

Educational Innovations, Inc.
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NEW!

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If you are looking to gross out some friends and family (and carry out serious scientific analysis at the same time) you will want to try out our bacteria growing kit. It includes everything you need to get started - you just supply water and bacteria (don’t worry, it’s everywhere.) This is perfect for science fair experiments because so many variables can be tested for bacteria growth.

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INTERACTIVE WORD WALLS

Create a tool to increase science vocabulary in five easy steps.

By Julie Jackson and Rose Narvaez
It is common to see word walls displaying the vocabulary that students have learned in class. Word walls serve as visual scaffolds and are a classroom strategy used to reinforce reading and language arts instruction. Research shows a strong relationship between student word knowledge and academic achievement (Stahl and Fairbanks 1986). As a result, building academic content vocabulary is an important part of science instruction. To support vocabulary development in science, we use interactive science word walls that resemble graphic organizers, strategically target academic vocabulary, and are student generated.

When students were asked to describe how interactive word walls supported their learning, the overwhelming majority of students not only said that they were better than traditional word walls, but many identified ways in which the word walls helped them. For example, one student stated that the word wall “helped me because whenever I forget I could just look back, and it gave me good information.” Additionally, students stated that it “helps remind us of what we have learned” and “since it is always up there I always remember.” This article describes five steps that show how to plan and construct interactive word walls and shares the experiences of fifth-grade teachers at 10 inner-city elementary schools who use interactive word walls to support science instruction.

Traditional word walls (Figure 1) are teacher-generated, unorganized lists of words that are posted on classroom walls. Many are posted at the beginning of the school year and then left alone. As a result, they are not current with instruction and not used or valued by students. Interactive word walls are an effective instructional strategy because they present current academic vocabulary while providing visual representations that help students develop “an understanding of, and fluency in, key unit vocabulary” (Douglas et al. 2006, p. 328). Additionally, word walls that include visuals differentiate instruction for English language learners (Carr, Sexton, and Lagunoff 2007). English language learners often struggle with the academic vocabulary included in technical readings or expository texts they are exposed to in science classes. Figure 2 (p. 44) contains an example of this type of word wall. The key learning concepts are clearly labeled and organized to support learning. The words light, refract, and reflect are easily viewed from across the room. The folded headings organize the wall and contain definitions. Notice the mix of real items and pictures of everyday objects that reflect and refract light. If the actual items (realia) were available, they were added to the wall. Color pictures were substituted when realia was not available or too big, too valuable, or too heavy to display. Interactive word walls are planned by teachers but created by students during the school day. Participating teachers report that their students “enjoy drawing, writing, and bringing items from home to contribute” to the wall.

Student participation in creating and maintaining interactive word walls is crucial. We ask students to supply the items (realia) and assign finding objects or examples...
for the wall as homework. Students can prepare labels, write definitions, create illustrations, and suggest relevant connections and patterns. The connections that they make are insightful and often surprising. “Ooh! That would be a great thing to add to the wall!” and “Can I make the card?” are typical student responses.

Because we construct these walls during class discussions, we frequently include items and tools from our inquiry science activities. This supports deeper understanding of disciplinary core ideas by providing multiple opportunities for students to contribute and interact with the objects displayed on the word wall while connecting core science concepts, inquiry experiences, scientific tools, and academic vocabulary.

The lesson described in this article applies to the Next Generation Science Standard disciplinary core idea Matter and its interactions (5-PS1-3): “Make observations and measurements to identify materials based on their properties” (Achieve Inc. 2013, p. 38; see Internet Resources).

Building a Word Wall

Step 1: Planning the Word Wall

Determine Vocabulary Needs

Purposeful planning provides opportunities to plan instructional activities that focus on core science ideas, performance expectations, and vocabulary with fidelity—all while heeding district guidelines. It also provides time to understand the grade band endpoints vertically, answering the questions of what has been taught, what needs to be taught, and what will be taught in future grades. We look closely at our grade level disciplinary core concepts and performance expectation verbs in order to understand the depth of knowledge, rigor, and intent of the standard and to identify essential vocabulary. We also identify crosscutting concepts, looking for ideas and practices that cut across all of the science disciplines.

First we distinguish between familiar (prior knowledge) and new vocabulary. We determine familiar vocabulary by looking at the previous grade level science standards. Vocabulary words that students learned in prior grades and may have forgotten are considered familiar vocabulary, and they will be direct taught. Sometimes we include these terms on the word wall under the heading “Words You Know.” New vocabulary is introduced through inquiry and targeted during classroom explanations and discussion and posted on the word wall. Next, we identify multiple meaning words, affixes, and root words related to the core science standard. Since many science terms have Latin origins, we also look for Spanish-English cognates. These will be introduced in context and included on the wall. Then, we determine target vocabulary related to the core science standard and plan ways to support these words during instruction. The vocabulary choices should be flexible and allow for additional words that emerge during instruction. We also look for crosscutting patterns and connections that we can use to structure or frame our word walls.

The next step is to pair selected words with pictures or real objects. We like to use real objects when possible. If the real items are not available, we use pictures or photographs. These do not need to be elaborate. Their purpose is to help students (especially those who are ELLs) make quick and easy visual connections to vocabulary.
Once target vocabulary and phrases are identified and matched with pictures or realia, we sketch a concept map to organize content and connect the vocabulary. To determine the best way to represent the information, we ask ourselves about the nature of the content: Does the concept have a hierarchical structure that can be divided into categories and subcategories? Is this concept a cycle? Do students need to compare and contrast topics? Explore cause and effect? Examine structure and function? Recognize scale, proportion, and quantity? Classifying matter by physical properties will require students to compare and contrast information.

Patterns and connections related to the science standard determine the concept map or framework used to structure the word wall. For example, flow maps easily illustrate the flow of energy in a food chain, while a web concept map may be used to represent the flow of energy in food webs. Some core science concepts lend themselves to circle maps, continuum/time lines, tree maps, or T-charts. A tree map sketch of an interactive word wall is shown in Figure 3. Photos of interactive science word walls are available at the Science Toolkit Facebook page, and the Achievement Strategies, Inc. website (see Internet Resources) contains a nice list of graphic organizer templates (see Internet Resources).

Completed sketches become blueprints for the word walls. This process organizes information within a unit, just as a graphic organizer would. The classroom word wall functions as a unit organizer that students can easily reference to help them organize content and support vocabulary development as the unit progresses. Students even encourage each other to “look at the wall, the answer is there.” Teachers use the walls, too. “Once I get my wall up, I find myself referring back to it to tie concepts together or to review.”

**Step 2: Create a Student Worksheet**

After we identify vocabulary and sketch the interactive word wall, we prepare a student worksheet that mirrors our sketch. Students are given copies of the organizer worksheet that they complete as the word wall is constructed during the unit. Figure 4 (p. 46) contains a student organizer for the fifth-grade Texas science standard “classify matter based on physical properties” (TEKS 5.5A) which supports part of NGSS standard 5-PSI-3 “Make observations and measurements to identify materials based on their physical properties” (Achieve Inc. 2013, p. 38).

**Step 3: Place the Word Wall**

Once we have selected vocabulary, have an idea of how specific concepts are linked, sketched the word wall, and prepared the student organizer worksheet, we are ready to place the word wall frame in our classrooms (Figure 5, p. 47). Wall space and room arrangements often determine the configuration and placement of word walls. They may be arranged on cupboard or classroom doors, on classroom walls, on windows, or hung from the ceiling with wire. Maximum instructional potential and efficiency is achieved when interactive word wall construction is aligned with lessons and students are allowed to participate in the construction process. As a result, walls are usually built across many days and are finished as a unit nears completion.

**Step 4: Build the Wall in Class**

Once the word wall is placed, we are ready to build the wall with our students. We like to plan and structure instruction around the construction of the word wall. We strategically introduce target vocabulary and highlight connections to previously established words or concepts during instruction. Each column of the properties of matter interactive
word wall (see Figure 6, p. 48) is completed during lesson discussions or following experiments that cover individual physical properties. For example, once students have planned and carried out investigations to determine which objects are magnetic or not magnetic, they add the items to the Magnetism column under the proper heading “is magnetic” or “not magnetic.” This process is repeated for physical state (solid, liquid, gas), solubility, relative density, insulator, and conductor. To support classroom management, students are permitted to add items as directed by their teachers during discussions and explanations. Interactive word walls might appear cluttered or messy to visitors but not to students who were present as each section was built. Because students participated in building the word wall, they take great pride in sharing them with others. When asked to explain their word walls, students eagerly share what elements they contributed and explain the inquiry experience that the wall represents. At the end of a unit they frequently ask, “What’s going on the next wall? Can we make it?” A teacher stated, “I find that my students are taking more ownership of their learning when they help create the word wall and see the direct application of knowledge and information.”

**Step 5: Complete Student Record Sheet and Word Wall Together**

Student organizer worksheets mirror the word wall. As the word wall sections are completed, students fill in corresponding sections of their organizer. As a result, the students have a copy of the word wall in their possession.
These sheets track daily instruction and may be used as formative assessments. Teachers may need to adjust instruction after looking at student organizers and noticing that students have not recorded information correctly, have confused concepts, or included inappropriate examples. Students usually glue the organizers into their science notebooks at the beginning of a unit. We like to take photographs of completed word walls and give copies of the photos to the students to glue into their notebooks at the end of their unit notes. This creates visual bookends of the learning experience. Additionally, a photo helps us remember how we organized the walls and eases the planning burden year to year.

The following sections introduce a word wall rubric that we share with teachers who want to improve their current word walls or who wonder if their initial attempts to create interactive word walls meet expectations. Additionally, we describe challenges that teachers have encountered and provide solutions that might help others faced with similar constraints.

**Good, Better, Best Word Walls**

A good, better, best rubric (Jackson, Tripp, and Cox 2011) that we use to guide word wall construction and structure teacher reflection is shown in Figure 7 (p. 49). It can be used to determine if word walls are interactive. Administrators use it during school tours to help them determine if word walls are good (traditional) or best (truly interactive and student generated). This rubric outlines the steps needed to transform a traditional word wall, which is generally a list of words, into a powerful interactive teaching tool that involves students, organizes content, and better supports learning. Interactive word walls that are rated...
“Best” are current with instruction, include words that are visible from a distance, are arranged to illustrate relationships and organize learning, are student generated, and contain visual supports.

Challenges and Solutions

The most challenging part of the interactive word wall process is finding time to plan and sketch the concept map. Early release and planning days provide extra time that we use to plan and sketch unit word walls. Also, making the word wall interactive for students can be logistically difficult. Putting the walls in locations that allow easy access helps students use the walls and add items for display or reference vocabulary and definitions. Deciding when and how to rotate word walls is also challenging. Wall space is a factor in most classrooms, making it difficult to display multiple word walls simultaneously. We recommend leaving the walls up as long as possible. Once we have finished using the walls we move them into the hall. Teachers sometimes build their boards on trifold science fair boards or chart paper to facilitate moving them. Having the necessary supplies is also a challenge. Students, parents and other teachers have been quick to respond to our requests for supplies, and a local grocery store provided small denomination gift cards that we have used to purchase items found in their store. Finally, certain science topics are easier to work with than others. However, given these challenges, we believe it is well worth the effort and make time to plan and implement interactive science word walls. Why? Identifying and defining terms does not deepen understanding if students do not understand connections between concepts.

Conclusion

Interactive word walls are an effective teaching strategy (Jackson and Ash 2011; Jackson, Tripp, and Cox 2011). They support the development of scientific thinking; build academic vocabulary; and reinforce important pat-
Interactive word walls are useful to students not only in unifying related terms and concepts, but also in helping students visualize connections between vocabulary, inquiry experiments, their own interests, and experiences.

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**References**


**Internet Resources**

Achievement Strategies, Inc. www.achievementsolutions.com/graphOrgTemplates.html

NGSS Table: 5-PS1 Matter and Its Interactions www.nextgenscience.org/5ps1-matter-interactions

This paper discusses challenges and opportunities expected as English language learners (ELLs) engage with Next Generation Science Standards (NGSS). We subscribe to a view of language learning and proficiency that is most concerned with students’ ability to use language to function in the context of their lives both in and out of school. We have discussed this view of second language acquisition and its implications for the science classroom in greater detail in a separate paper. Here, we concern ourselves with learning opportunities for ELLs in an English-speaking science classroom in which NGSS have been implemented based on the National Research Council (NRC, 2011) document “A framework for K-12 science education: Practices, crosscutting concepts, and core ideas” (hereafter called “the Framework”).

The Framework (NRC, 2011) refines and deepens the meaning of the term “inquiry-based science” by identifying a set of science and engineering practices. These practices are both a representation of what scientists do as they engage in scientific inquiry and a necessary part of what students must do to learn science and understand the nature of science. There is a parallel between the Framework’s assertion that learning science requires students to engage in these practices, and our claim that meaningful “language for use” learning occurs in contexts where students are required to communicate (speak, listen, read and write) about science. A practice-oriented science classroom can be a rich language-learning as well as science-learning environment, provided teachers ensure that ELLs are supported to participate. Indeed it is a language learning environment for all students, as the discipline itself brings patterns of discourse and terminology that are unfamiliar to most of them. In this context, teacher knowledge about language and language learning support strategies can improve the overall science learning experience of all students, especially of ELLs. We do not suggest that science teachers should function as language teachers, but rather as supporters of the language learning that occurs in a content-rich and discourse-rich classroom environment.

Next Generation Science Standards: Focus on Science and Engineering Practices
The Framework defines science learning as having three dimensions: (1) science and engineering practices, (2) crosscutting concepts, and (3) core ideas in each science discipline. The central content of the Framework document is a detailed explanation of what is intended in each dimension, how the three dimensions should be integrated in curriculum and instruction, and how these dimensions progress in sophistication across K-12.
The framework defines eight science and engineering practices:

1) Asking questions (for science) and defining problems (for engineering);
2) Developing and using models;
3) Planning and carrying out investigations;
4) Analyzing and interpreting data;
5) Using mathematics and computational thinking;
6) Constructing explanations (for science) and developing designs (for engineering);
7) Engaging in argument from evidence; and
8) Obtaining, evaluating and communicating information.

Engagement in any of the practices involves both scientific sense-making and language use. The practices intertwine with one another in the sense-making process. This sense-making is a key endeavor for students as it helps them transition from their naïve conceptions of the world to more scientifically-based conceptions. In particular, we focus here on four of the eight practices, namely 2, 6, 7 and 8. These four practices are selected for the following reasons.

First, these practices represent a major shift. Even where science has been taught in an activity rich “inquiry-based” classroom, the practices related to investigation have often been stressed without an equivalent stress on the four sense-making practices highlighted here. Particularly in the lower grades the activity often ends at the stage of recording observations, with minimal attention paid to interpreting them and almost no attention to constructing models or explanations and refining them through argumentation from evidence.

Second, these practices are deeply interrelated because each is used to support effective engagement in the others. Argumentation from evidence requires students to apply both mental and diagrammed models that clarify their thinking and to develop model-based explanations using evidence (data and observations), logic, and information obtained from outside sources or prior experience. To develop an explanation and examine its success or failure in explaining all the evidence about a phenomenon or system requires argumentation. Clearly students must obtain, evaluate and communicate information as they engage in the process of building and critiquing explanations.

Third, engagement in these practices requires classroom science discourse, which demands both receptive and productive language skills. Students read, write, and visually represent as they develop their models and explanations. They speak and listen as they present their ideas and engage in reasoned argumentation with others to refine them and reach shared conclusions. This offers rich opportunities and demands for language learning at the same time that it supports science learning. Hence these practices merit special attention in science classrooms that include ELLs.

Finally, teachers implementing these practices need an understanding both of the practices and of strategies to engage all students in them regardless of students’ English proficiency. The classroom culture of argumentation must be developed and supported to ensure that all voices are respected and included, even as the process reveals flaws in a student's model or explanation or limitations of their language proficiency.
Intersections between Science Practices and Language Learning
The learning of school subjects takes place through the use of language in oral and written forms. This section addresses two issues: (1) language skills involved as students engage in science and engineering practices and (2) features of science text and science talk.

Language Intensive Tasks to Engage in Science and Engineering Practices
Students develop facility with all of the eight science practices by using them in a concerted way to support sense-making about a phenomenon or system. Through an iterative cycle of engaging in these practices students develop understanding of science. Language is essential to successfully engage in any of these practices and all of the practices provide language learning opportunities, particularly the four that we discuss below. Engagement in these practices in the classroom both demands and affords rich student discourse. The discourse of the science classroom, and of science textbooks as well, differs from the everyday discourse of students and from that of a mathematics or language arts classroom or textbook. It is also distinct from the professional discourse and writing of scientists though it mirrors the conventions of that discourse more closely as the students advance across the grades.

The teacher must define and facilitate a classroom culture of discourse. This culture should be inclusive, accepting contributions for their meaning and their value in the discourse however flawed or informal the language of the speaker. It should support students to maintain a spirit of shared sense-making and discovery while they question others, ask for further explanation, and provide arguments that refute an idea expressed. Most importantly for ELLs, it allows students to hear many examples of the discourse that they are expected to produce.

Below we elaborate on the four highlighted practices, stressing the language learning opportunities that they provide as well as their roles in science learning.

Developing and Using Models. Each phenomenon or system under investigation demands description via a model. In developing a model, students operate with language and diagrams as well as with observations of the system in question. The model may include reference to a graph of some data or an equation describing a relationship between quantities. Precise observation demands both precise descriptive language – of which many examples must be provided – and carefully constructed diagrammatic representation. Diagrams can display both the seen (e.g., objects) and the inferred (e.g., force arrows, energy flow across an imagined system boundary) aspects of the system. Diagrams and graphs require labels to help students communicate all that has been observed and inferred about the system.

At all grades students can produce, describe and apply models of a system under study. What progresses across the grades are the sophistication and abstraction of the models that they work with and of the language and diagrams or other representations contained within their description of their model. This progress is aided when the teacher leads students to discuss examples of models, as well as ways to describe them that incorporate higher-level features. The interplay between diagrammatic representations of models, or three-dimensional models, of a system and the language used to describe these representations both builds students’ conceptual understanding of the system in question and refines their ability to talk about it. Teaching strategy and repeated practice develops students’ ability to make explicit a mental model of a system or process, expose contradictions between observations and the current mental model, and modify the mental model toward a more scientifically-supported one.
The practice of developing and using models provides an initially nonverbal way to express a thought or an understanding. Using models to explain and describe systems provides students an impetus to name aspects or parts of their own model and to speak about how it explains observations. In doing so, students refine their understanding of needed scientific terminology. With a model in hand students can say “this piece here . . .” and then have a reason to want to know that the piece is called a cog or a flagellum. This helps students to learn appropriate language in context as they express their ideas and grow in their understanding of the system under study.

Models are useful as more than a record of observation – they support the development of explanations for phenomena. As students support their explanations with reference to their models, their thinking is made more visible and explicit, both to themselves and to others. Language is the essential tool for them to engage in explanations and arguments with their peers around the model at hand. Students’ ability to use language precisely is supported by the visual representation of their model. For ELLs the progression from observation of a system to modeling a system, to using language about the system, provides a rich language-learning experience where the learning is driven by the classroom discourse around the objects and ideas being considered and represented.

Developing Explanations (for Science) and Designing Solutions (for Engineering). The process of science is to make ever more precise and explicit explanations of phenomena, while engineering likewise requires precision and explicit features in a design solution. The level of explicit detail of observation and explanation required by science and engineering is not common in everyday experience; it demands a comparable level of precision in language use. Models are an important step in the development of an explanation of how something happens or of an idea for a design solution. When students are provided examples of diagrams and descriptions of models and then diagram and describe the model that underlies their proffered explanation or design, they become more explicit about their ideas. This move toward explicit detail occurs even when students do not yet have the language to be explicit if simply asked for a verbal explanation or design proposal. Thus like the process of developing models, the process of developing explanations and designs involves language development, mediated by diagrams, lists, charts and other elements of models and observations and examples of the types of verbal explanations that are the end goal of student learning.

As students are asked to explain their ideas or designs and critique those of others, including written examples, they learn from the experience of encountering multiple examples of the level of precision and detail that scientific thinking requires. Likewise students’ ability to use technical terminology develops because they need the precision that it offers. This process needs teacher support but it is not helpful to insist on distinctions in terminology for which the student does not yet have access to distinctions in concept. This is particularly true for words such as energy that have an everyday usage broader and less defined than their scientific meaning. The development of correct scientific language usage comes from the development of scientific concepts through experience and application; it cannot be achieved by learning definitions. In this sense all students are language learners.

Engaging in Argument from Evidence. Argument is a discourse practice, whether practiced in writing or verbally. Across all disciplines an argument can be deconstructed as a claim and the logic and evidence used to support or refute that claim. What counts as evidence is discipline-specific. In science what counts as evidence is data and observations. Hence argumentation in
science is not a purely verbal exercise. It is an exercise in the coordination of language and experience and thus another rich language learning opportunity.

As students analyze written examples of arguments they learn the characteristics of a strong scientific justification of a claim and they learn to identify weak support. As they engage in argument with others to arrive at a shared “best” explanation or model, they are motivated to clarify both their language and their thinking by the atmosphere of shared interest and goals.

**Obtaining, Evaluating and Communicating Information.** This practice, more than any other, points to reading and writing as well as to listening and speaking. It is here that the student meets the difficulties of reading and interpreting scientific writing, though typically not at the level of scientific papers. The writing in question is that of textbooks, science-related trade books, websites and popular articles about science. Each of these genres has different language conventions.

Particular challenges for ELLs arise when they are asked to read textbooks or other written materials about a science topic. Challenges can be of two types. First, ELLs may not have developed strong reading skills if their previous ESL instruction primarily focused on grammatical structures. They will therefore need support in the development of reading comprehension proficiencies. Second, the language style and complexity of texts written for science learners is different from those of other written genres encountered in other school subjects and from spoken language, as we discuss below. Thus all students need support and strategies for reading these materials.

Students need multiple opportunities to write after they have been guided in examining examples of the type of writing that is required. For example, if students are to be asked to regularly use journals to develop and express their own understanding and to engage in metacognition about it, they need to see examples of such writing. Similarly, before they are expected to give oral presentations and written reports that demonstrate what they have understood or to describe an investigation or design project, they should be given examples of such presentations and reports. The point of this work is science understanding and science communication; these exercises should not become tests of accuracy and fluency of language production. Opportunities to revise and correct are appropriate for formal reports; however, for journal writing the emphasis should be on rethinking rather than on rewriting. Nevertheless students must understand what writing that reflects thinking looks like as well as what it includes and does not include.

**Features of Science Language**
It is helpful for science teachers to understand that not only technical terms, but also other features of science text and science talk, may make them difficult for students to understand. All students encounter these difficulties, but problems may be magnified for ELLs who have not had access to good instruction. We here briefly review these features.

**Science vocabulary.** As they engage with science students need to code-switch from everyday uses of language to the language of science (Brown & Ryoo, 2008; Moje, Collazo, Carillo, & Marx, 2001). Within science vocabulary there are different types of challenges for students. First, some everyday words have science-specific meanings that are different from or more narrowly-defined than their everyday meanings (e.g., *force, energy, work, cell, space, fault*). Second, general academic vocabulary that is used across disciplines (e.g., *compare, infer,*...
analyze, evaluate; tier II words according to Beck, McKeown, & Kucan, 2002) present challenges. Third, discipline specific words invented and defined for science use (e.g., gene, biome, proton; tier III words according to Beck et al., 2002) are new to most students, even those with fluency in everyday English. Finally, even everyday words can make subtle shifts in meaning as they are used in science. For example, in everyday English, “Why did that happen?” may be asking about the motivations of those that made it happen, whereas in the natural sciences it is asking students to restrict their attention to the mechanisms and conditions that caused the effect.

Science Discourse. Each area of science has different disciplinary discourse conventions, adapted to what has proven effective and efficient for communication among experts. Learning the register of discourse of a discipline is a form of socialization into how members of the discipline talk, write, and participate in the knowledge construction. These differences are reflected in science textbooks and classroom talk, which have registers specific to a discipline and grade level. Students must absorb these differences in register as they work to construct meaning appropriate to the topic at hand.

Science discourse at any level requires students to attend to and argue about precise meanings. This demand for attention to precision and attention to detail goes beyond the meaning of technical vocabulary, to the evidence and logic of connecting cause and effect, and the validity of claims or warrants. Students must develop an understanding of the forms of this discourse as well those used in written science text.

Multiple Modes of Representation. Science information is conveyed not just through oral or textual forms but also through visual and mathematical representations, including pictures, diagrams, graphs, charts, tables, maps, and equations. Students need to master these non-linguistic modes of representation to gain an understanding of science. In addition they need to coordinate information presented through the various modes into a single coherent understanding of the material being presented or a coherent presentation of their own ideas. For ELLs the coordination of these multiple representations provides an additional path to language learning, as well as to science learning.

Science Texts. Discipline-specific texts written for learners typically have particular features that over time have been thought to provide the most effective way for the content of that discipline to be expressed. It is helpful for students to examine these features and discuss why they are used. Recent analyses of the written language of secondary science texts carried out from the perspective of Systemic Functional Linguistics have found that these text structures are complex and include lexical, syntactic, and discourse structures that are not typically present in everyday language (Fang & Schleppegrell, 2008; Halliday & Martin, 1993; Halliday & Matthiessen, 2004; Schleppegrell, 2004). Key features include:

- Authoritativeness to “suppress” human agents behind events, concepts, and discoveries and to render the scientific discourse more objective or timeless through simple present tense, passive voice, generalized or virtual participants (‘scientists,’ ‘research team members’), and hidden evaluations (‘claimed,’ ‘confirmed’).

- Nominalization of verbs or adjectives into nouns to economically summarize sentences into one abstract noun phrase.
• Long and complex noun phrases and clauses to effectively pack complex content within shorter sentences

• Technical vocabulary to use terms with specialized meanings in science lexical density to “pack” texts with more information

**Supporting Science and Language Learning for ELLs**

We note five areas where teachers can support science and language for ELLs: (1) literacy strategies with all students, (2) language support strategies with ELLs, (3) discourse strategies with ELLs, (4) home language support, and (5) home culture connections.

**Literacy Strategies.** In science classrooms, effective teachers incorporate reading and writing strategies in their instruction to promote both science learning and literacy development for all students (Douglas, Klentschy, Worth, & Binder, 2006). These strategies include activating prior knowledge, having explicit discussion of reading strategies for scientific texts, prompting students to use academic language functions (e.g., *describe, explain, predict, infer, conclude*) in science practices, requiring and exemplifying scientific genres of writing (e.g., keeping a science journal, investigation or design reports, conference posters), teaching the uses of graphic organizers (e.g., concept map, word wall, Venn diagram), encouraging reading trade books or literature with scientific themes, and providing journal writing prompts (e.g., *I observed…*, *I noticed…*, *I wondered…*, *I inferred…*) as part of an investigation protocol.

It is not a service to language learners to “protect” them from the demands of subject area reading. If they are to reach grade level understanding of a topic, they will need strategies for reading the relevant text and interpreting its complex sentences, as well as for linking these to diagrams, data charts and equations that appear in the same section. In supporting students to read and understand scientific texts, it is more important to provide them with strategies for sense making and ways to “decode” complex sentences and to coordinate text and diagrams than to provide vocabulary lists and glossaries. Word definitions are indeed sometimes needed but they are better learned by use in context than by memorizing a vocabulary list. Dictionary use is likewise a helpful but limited strategy. (However, ELLs should be encouraged to use an English to English dictionary to interpret unfamiliar words before resorting to a translation dictionary.)

Students are expected to learn how to describe, explain, and predict phenomena in science-specific genres of writing (Hand, Wallace, & Yang, 2004; Palincsar & Magnusson, 2001). They need to report science investigations and design projects in multiple-mode formats (e.g., those that include written description plus graphs of data, diagrams of equipment or observations). Additionally, students need to code-switch from everyday uses of language (e.g., telling or writing stories) to the language of science (Brown & Ryoo, 2008; Brown & Spang, 2008). To perform the kinds of writing tasks described here, all students, but particularly ELLs, benefit from multiple examples of the desired product, annotated and discussed by the whole class or in small groups to examine the organizational structure and particular features. For example, without teaching the passive voice as such, teachers can certainly call students’ attention to the fact that all the actions in a particular paragraph have no specified agent (e.g., data are examined, conclusions are reached) and that this is a common feature of scientific writing.

ELLs’ needs with respect to written materials used in science class require ongoing attention from teachers. The joint goals of science and language learning must both be considered as
strategies that are chosen to assist any student in mastering a difficult reading assignment. The appropriate strategy for a student depends on the student’s language level, reading level, and science comprehension level. The more the teacher is aware of all three through their observation (formative assessment) of the student, the better s/he can match the student’s needs.

Language Support Strategies
To support ELLs in learning science and developing English proficiency simultaneously, teachers engage students in purposeful activities, ensure that students experience multiple examples of language in use, and call students’ attention to the ways in which language is used to communicate meaning in science. They encourage students to communicate and reflect about ideas and to engage with others in sense-making talk and activity. They encourage non-linguistic modes of representation (e.g., graphs, charts, tables, diagrams, pictures), as well as language production. They guide students to comprehend, through use in context, key science vocabulary – both general academic terms ( tier II words) and discipline specific terms ( tier III words) (Beck et al., 2002). All these strategies for science teaching support ELLs, provided teachers ensure that these students are full members of the classroom science discourse community.

Student journals of their science activity and thinking are a major tool used in many science classrooms and they can also provide support for language learning. Students are encouraged to use their journals to record observations, develop explicit representations of their models, and analyze their experiences and understandings of what they are learning in science. This is not formal science writing; it is writing to make thinking explicit. Journals become an effective tool only if they are used regularly and if in-class time is provided for reflective writing about what has just occurred in an activity or a discussion. Early stage ELLs may gain science understanding by doing this writing initially in their first language if they have been instructed in this language, but should be encouraged to then restate (rather than to translate) this thinking in English. As language proficiency in English develops, the student should be encouraged to transition to thinking and writing in English.

Discourse Strategies. Discourse strategies can be used to enhance ELLs’ understanding of academic content (i.e., adjust the level and mode of communication). Discourse strategies focus specifically on the teacher’s role in facilitating ELLs’ participation in classroom discourse (Gibbons, 2006). A major challenge for teachers is in how to structure activities so as to reduce the language barrier for participation while maintaining the rigor of science content and processes.

The implementation of science and engineering practices demands that students work and talk with one another, sometimes in small groups, sometimes as a whole class. Classroom management strategies for students to engage in such work begin with the establishment of a classroom culture as to what is acceptable behavior. The mode of argument from evidence must be established, with norms that ensure civil discourse and respect for all speakers. Inclusion of ELLs in the discourse must be established (by example) as a part of this culture.

Further, one of the discourse conventions should be that any participant should feel free to say, “I did not understand what you said” and ask for repetition or clarification. Whether the lack of understanding is at its root linguistic or whether it depends on the conceptual clarity of what has been said, the respectful back and forth of questioning and responses will lead to the further
development of understanding of science concepts and of the language needed to discuss them.

Teachers need to recognize ELLs’ varying levels of developing language proficiency and adjust norms of interaction with a student accordingly, for example, by using clearer enunciation or longer periods of wait time. They provide students with multiple redundancies of the same concepts, for example, using synonyms or paraphrases of difficult language, repeating and rephrasing main ideas, or recasting and elaborating on students’ responses (Gibbons, 2006). If they have beginners in their classes, they determine which students can and cannot understand whole class explanations and they provide alternatives for those who need such alternatives. They use multiple modes of representation (gestural, oral, pictorial, graphic, and textual) to communicate meanings. They amplify rather than simplify their presentations, expressing concepts in multiple ways (van Lier & Walqui, 2010).

A student with an idea to share will want to express that idea. Often the language used to do so will not be “correct” either in the sense that the words used are not the correct technical terms, or that the grammar of the sentences is non-canonical. If these normal characteristics of emerging English are corrected, the discourse becomes stilted and the student’s urge to speak is suppressed. A teacher needs to mediate such discussions to ensure that poorly-expressed ideas are being heard and considered by others, not to ensure that the students speak correctly. Asking questions to elicit amplification or clarification of an expressed idea is an effective strategy. Asking students to restate in their own words an idea just expressed by another provides chances to speak, to clarify an idea, and for the teacher to check whether other students have followed what was said. This exercise can begin with a good idea that was well expressed, or one that was poorly expressed. Either way, the repetition and ensuing discussion reinforce the idea and the language needed to talk about it. Both precision and correctness in language use develop from repeated experiences, and from models offered by the teacher in summarizing or interpreting a student’s statement.

**Home Language Support.** It is important to draw a distinction between home language instruction (i.e., bilingual education) and home language support (Goldenberg, 2008). Even in the absence of bilingual education programs or fully-trained bilingual teachers, ELLs’ home language can be used as instructional support for their learning of academic content and processes in English.

In the science classroom teachers can build upon and make use of students’ home language to support science learning in English. If teachers share the same home language as their students they can use the home language to communicate and reinforce key science vocabulary and concepts (Hudicourt-Barnes, 2003). They can also allow students to communicate using combinations of their first language and English, referred to by Garcia (2009) as “translanguaging.” If teachers do not speak students’ home language, the home language can still be supported through a number of strategies. In the beginning of a lesson, teachers may introduce key science terminology in both the home language and English. Teachers may highlight cognates as well as false cognates between English and the home language. For example, Spanish and other Romance lexicon are often derived from Latin, the primary language of science. Bravo, Hiebert, and Pearson (2007) found that approximately 88% of key science words selected for instruction were cognates in Spanish and about half of them were high-frequency words in Spanish. Such cognates are likely to be known by Spanish speakers, even those with limited schooling in their first language.
In a bridge period for students entering with very limited English, teachers may encourage bilingual students to assist them in their home language as well as in English, allow ELLs to write about science ideas or investigations in their home language, and invite family and community members to participate as local experts in classroom literacy events. When students are asked to engage with other students in their common home language, a small group discussion is preferable to a single student “translation,” which may transmit the conceptual errors of the speaker. The small group should also be asked to communicate their conclusions to others in English.

**Home Culture Connections.** While making connections to ELLs’ home language is quite concrete, the notion of making connections to their cultural experiences in relation to academic content can be more abstract and subtle. Since science has traditionally been regarded as “culture-free,” incorporation of home culture into science instruction is often ignored. Most science educators need a better understanding of how to articulate connections between home culture and school science (Lee, 2002; Warren, Ballenger, Ogonowski, Rosebery, & Hudicourt-Barnes, 2001).

The literature on cultural congruence indicates that students participate in classroom interactions in ways that reflect culturally-based communication and interaction patterns from their home and community (Gay, 2002; Villegas & Lucas, 2002). Teachers need to know how different students might be more or less familiar with the participation norms that are expected in science classrooms, what interactional patterns are common among different groups of students, and how these patterns might foster or constrain students’ participation in science classrooms. Teachers must balance considerations of culturally-based patterns of communication and interaction with the risks of applying stereotypes or over-generalization based on students’ cultural backgrounds. Teachers make the norms and expectations for classroom discourse explicit and look for opportunities to honor the full range of student discourse patterns when appropriate. For example, cross-talk (talking simultaneously with other speakers to add to what they are saying) is completely acceptable in some cultures, while it is considered rude and disruptive in other cultures including the cultural norms in most U.S. schools (Lee & Fradd, 1996).

The literature on funds of knowledge indicates that the lived experiences of students at home and in the community can serve as intellectual resources for academic learning (González, Moll, & Amanti, 2005; Moll, 1992). In science classrooms teachers ask questions that elicit students’ funds of knowledge related to science topics (Solano-Flores & Nelson-Barber, 2001). They use cultural artifacts and community resources in ways that are academically meaningful and culturally relevant. These cultural connections can be of great assistance as ELLs strive to integrate prior experiences with new academic expectations. For example, Rodriguez and Berryman (2002) worked with high school students in predominantly Latino and impoverished school settings in a U.S.-Mexican border city. Using a curriculum unit on investigating water quality in their community, the students engaged in authentic science as they explored how this topic was socially relevant and connected to their everyday lives. Having come to see science as relevant to their lives, students saw scientific investigations as worthwhile for themselves and for students in other schools in the region.
References


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