Supporting Science Learning through Science Literacy Objectives for English Language Learners

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Abstract. The author provides information on how science teachers can write science literacy objectives that help English language learners (ELLs) develop the scientific literacy needed for academic success in the science classroom. The article offers suggestions on how teachers can determine the vocabulary, language functions, and sentence structures that their students need to engage in critical thinking in science. An approach for collaboration with students’ English as a second language (ESL) teacher is discussed.

Key words: English language learner, language functions, scientific literacy, sentence frames, vocabulary

The definition of literacy in the U.S. educational context has moved from the limited idea of simply being able to read and write to a more expanded definition that includes many different types of literacy, especially scientific literacy. Students who are scientifically literate are able to (a) demonstrate basic skills common to all literacy (namely, proficiency in the language of the text [Burkhardt et al. 2003], which is English in the majority of U.S. classrooms); (b) “ask, find, or determine answers to questions derived from curiosity about everyday experiences”; (c) “describe, explain, and predict natural phenomena”; and (d) “read with understanding articles about science” (Burkhardt et al. 2003, 18).

With this expanded view of literacy in mind, teachers need to consider how the learning challenges of students who are English language learners (ELLs) differ from native English speakers in our science classrooms. In regard to basic literacy, the requirement of language proficiency in English is a relatively straightforward one for students who are native speakers of English. Because they already have a reasonable command of the English language, their task is mainly to learn the scientific vocabulary needed to support the development of their scientific literacy. For many of them, this is a considerable task in itself. For those students who are ELLs, however, the task is much greater. These students are still acquiring English as a second language and developing their basic literacy skills in English. At the same time, they are called upon to (a) locate information in science texts; (b) interpret and apply that information; and (c) ask, answer, describe, explain, and make predictions about science—all in a language which is still in its developmental stages. This difference in the science literacy skills of ELLs and native English speakers results in what Au and Raphael (2000) refer to as a literacy gap.

Conversational versus Academic Literacy

Despite this gap, it is sometimes not immediately apparent that many ELLs need help to develop their science literacy skills. Teachers frequently overhear ELLs having casual conversations with fellow students in relatively fluent English. This conversational English, or what Cummins (2001) calls basic interpersonal communication skills (BICS), takes 1–3 years for ELLs to develop. But these same ELLs who casually chat with their peers may have great difficulty read-
ing, writing, or talking about scientific concepts when the classroom lesson begins. The reason for this puzzling decline in classroom literacy abilities is that the kind of language used in science and other content areas is different from conversational language. It is academic language (e.g., speculate, hypothesize, approximate) that is less frequently used than everyday conversational language (e.g., greetings, exchange of personal information). In addition, academic language can be confusing when first encountered because of terms that sound similar to everyday conversational English but have different meanings (e.g., periodic table, animal class, autonomic response). This cognitive academic language proficiency (CALP) takes 5–7 years to fully develop (Cummins 2001). Students’ apparent decline in literacy abilities is, in reality, an indication of the need for more development in literacies relating to academic studies. In the discipline of science, literacy development can be achieved through writing and teaching science literacy objectives to strengthen ELLs’ academic literacy and thereby reduce their science literacy gap.

What Are Science Literacy Objectives?

Science literacy objectives focus on the literacy skills that all students need to effectively participate in science learning. They include the literacy skills needed to read, write, and orally communicate about science concepts and principles and to participate in science activities in a whole class setting or in group activities. These objectives are based on the specific content objectives of science lessons, and they include not only the vocabulary of science, but also strategies for effective reading, writing, listening, and notetaking, as well as the academic language functions needed to participate in science learning. Some of those language functions are:

- seeking information
- reporting and describing information
- comparing information
- classifying information
- analyzing information and identifying patterns
- hypothesizing outcomes, causes, effects, etc.
- describing solutions to problems (Chamot and O’Malley 1994)

How to Write Science Literacy Objectives

The science unit’s content objectives are the starting point for developing science literacy objectives. A useful technique is to answer the question, “What literacy skills do students need to use to achieve the specific content objectives of this particular lesson?” For example, in a Cell Inquiry lesson by Wilder and Shuttleworth (2004, 28), one of the objectives is that “students will be able to describe the differences between plant and animal cells.” To achieve this objective, students must be able to make statements that accurately describe the shape of the things that they see, such as “Animal cells have irregular shapes.” Another example comes from Miller’s (2004) science unit on Insects in the Classroom. Students are to investigate the behavioral responses of the milkweed bug, formulate hypotheses from the data they collect, and draw conclusions. One of the research questions that students are investigating in this lesson is “Do the insects show a temperature preference?” (Miller 2004, 26). Students make a hypothesis prior to designing and conducting their experiment. After conducting the experiment, they write a formal laboratory report. If ELLs are to participate in the activity, especially the writing of a laboratory report, teachers need to be sure they have the specific scientific literacy skills needed for this science unit. The level of their English language proficiency might limit the complexity of the language in their reports, but they can be successful in achieving the content objectives with supportive science literacy objectives. Science literacy objectives that support the content objectives of this science unit could be that students will be able to
• form a statement to make a hypothesis, such as “Milkweed bugs prefer warm temperatures”;
• know how to describe the method they used to test their hypothesis;
• write or orally describe procedures by using key sequence words such as first, then, after, next; and
• know how to describe their results and conclusions, such as “Milkweed bugs tend to avoid cold temperatures because they all moved to the warm end of the bug trough.”

If the content objectives of a particular science unit include the ability to make a verbal report about scientific findings, a supportive literacy objective might be that students will be able to organize and present scientific findings using visuals and speaking from note cards.

Probably one of the most common mistakes teachers tend to make when preparing science literacy objectives is to focus solely on vocabulary acquisition and not consider the structure in which that vocabulary is used. For example, in the Cell Inquiry lesson, students need to describe the shape of the cells they observe. To do this, ELLs certainly need to know specific descriptive vocabulary, such as smooth, rough, square, rectangular, regular, irregular, and patterned versus random appearance (see Figure 1). But they also need to know how to use that vocabulary within particular language functions. For example, students use the language function of describing when they say “The cells are shaped like rectangles” and “They are lined up in rows in a pattern.” Consequently, science literacy objectives for this unit should include not only vocabulary on shapes but also how to use that vocabulary in descriptive sentences.

Teachers can help their ELLs develop the ability to use science vocabulary in grammatically correct and fully formed sentences by providing sentence frames, also called sentence builders (Nattinger and DeCarrico 1992). Sentence frames are templates of language functions into which students can insert appropriate vocabulary words. They are ready-made chunks of language that help language learners develop fluency and communicate concepts without getting over-involved in grammar rules (Wood 2002). For describing the shape of the cells in the Cell Inquiry lesson, some sentence frames might be “It looks like ____” or “They are shaped like ____” (see Figure 2). For comparing and contrasting plant and animal cells, sentence frames might be “Animal cells are like plant cells because ____” or “Animal cells have different ____ than plant cells.” For the Insect lesson, students need to make a hypothesis prior to starting their experiment. A useful sentence frame might be “Milkweed bugs prefer ____.” Students also have to write a formal laboratory report describing the method they used to test their hypothesis. Useful sentence frames might focus on using sequence words, such as “First, I ______,” and “Next, I ______,” and “Finally, I ______.”

FIGURE 1. Vocabulary poster for Cell Inquiry lesson.
ELLs are still involved in critical thinking and inquiry about science, but now, with the help of the sentence frames and vocabulary, they are able to construct well-formed sentences to discuss their findings, both orally and in writing. The completeness of the sentence frame can vary, depending on the level of language proficiency and literacy skill that the ELLs have at that point of the school year. As ELLs become more proficient in their use of language and literacy skills, teachers can gradually withdraw some of the supports so their students assume more responsibility for their science literacy.

Besides including specialized science vocabulary and sentence frames of the different language functions (e.g., describing, classifying, explaining), science literacy objectives can also include strategies for science reading, writing, listening, and speaking and for participating in group work, an important aspect of inquiry science. For example, science reading is generally expository text, very different from the narrative texts students encounter in their language arts and social studies classes. Some ESL curricula focus heavily on comprehension strategies for narrative and personal experience texts at the expense of expository texts. Therefore, it is not unusual for ELLs to come to the science classroom unprepared to handle the heavy descriptive, procedural, and factual load of expository text. Science literacy objectives that help ELLs navigate through information-dense science texts can include reading strategies, such as using graphic organizers (e.g., Venn diagrams, concept maps) to make comparisons of cell traits, or using a summary strategy like Generating Interaction between Schemata and Text (GIST; Muth and Alvermann 1999) to underline 10 words or concepts that are key to understanding the text. ELLs can also use graphic organizers or key concepts lists developed during reading as writing prompts for their reports or other written classroom assignments.

**Why Science Teachers Are Key to Helping ELLs Develop Science Literacy**

Because science texts rarely include language structures or sentence frames and because many ESL textbooks focus on conversational language use, the collaboration between science teachers and ESL teachers is of critical importance to the academic success of ELLs. Although there are some new ESL texts that are based on academic content, science is not always one of the content areas for secondary level texts, or the content is not a close enough match to the school’s science curriculum to be useful. Thus, the science teacher becomes a critical source of information for the ESL teacher about the science literacy skills that ELLs need to participate more fully in science learning and activities in the mainstream science classroom. Conversely, in a truly collaborative environment, the ESL teacher can be a source of support for science teachers as they write their science literacy objectives for individual science units.

**Using the Resources of the ESL Classroom to Support Science Literacy**

Once the science literacy objectives are written, science teachers should share them with their students’ ESL teacher (or provide final versions if the ESL teacher participated in the development of the objectives). The ESL teacher can help ELLs develop not only their English language proficiency but also their science literacy skills. When science teachers share their science literacy objectives, the ESL teacher needs to know not only the key science vocabulary for upcoming science units, but also the language structures needed. For example, to prepare for the unit on Insects in the Classroom (Miller 2004), science literacy objectives may include the ability to use important science vocabulary such as response, tendency, preference, temperature, range, avoid, and congregate. In addition, because students will be studying about cause and effect, ELLs need to learn how to make if-then statements, such as “If I heat up the bug trough, then ________.”

In the ESL classroom, ELLs can preview, practice, read, write, and talk about science using sentence frames with the appropriate science vocabulary in a low-risk environment. Working on science language before they come to the science classroom gives ELLs the opportunity to become comfortable with using this type of academic language. Once ELLs become familiar with these basic sentence structures, they are more likely to (a) comprehend them when listening to teachers or to other students, (b) recognize and comprehend them in their science readings, and (c) use them orally in group or class discussions.
Informing Students about Science Literacy Objectives

After deciding on the unit’s literacy objectives and sharing them with the ESL teacher, the science teacher’s next step is to share them with their students and make the connection to the content clear. Literacy objectives should be posted prominently in the classroom, either on the board or on a poster at the front of the room. They should not just be given orally because ELLs might not remember them or might need more time to process the oral language. Posting them in writing in a prominent place gives ELLs additional time to comprehend them, but, even more important, it gives ELLs something to measure their progress against as they proceed through the unit. During and at the end of the unit, ELLs should engage in self-assessment on not only the content objectives but also the literacy objectives, asking themselves questions such as, “Am I able to describe the difference between animal and plant cells using correct vocabulary and appropriate sentence structures?” (see Figure 3). Science teachers can also engage in this process with their ELLs as part of ongoing assessment integrated with instruction.

Teaching Science Literacy Skills

Once content and science literacy objectives are posted and reviewed with all the students, science teachers can conduct a mini-lesson for their ELLs or even for the entire class, if needed. ELLs are not the only students who benefit from a focus on science literacy. Native English-speaking students who may have weak literacy skills can benefit from a mini-lesson embedded in the science instruction.

For example, in Wilder and Shuttleworth’s (2004) article on cell inquiry, students are to hypothesize on the composition of a “blob” of material they have been given. One possible literacy objective for this lesson is “I can use the right vocabulary and sentence structures to make and justify my predictions.” From this literacy objective, teachers can derive examples of the kind of sentence frames that students might use to accomplish this objective such as, “I think that the blob is composed of _______ because ________.” They can post this sentence frame in the room for students to refer to in their writing and in their oral discussions. A good place for a Sentence Frames poster is next to a Word Wall poster of the key vocabulary for the science unit. Teachers can model the use of the sentence frame, both orally and in writing, and ask the students to do likewise, using a sample “blob.” Teachers can also read examples of scientific language from texts, draw students’ attention to these examples, write them on the board for students, and also model English pronunciation for their ELLs.

Science Literacy Objectives Support Teaching and Learning Standards

Creating, sharing, and teaching science literacy objectives as part of science instruction support national science teacher standards as well as national ESL standards. Science Teaching Standard B of the National Science Education Standards (National Committee on Science Education Standards and Assessment, National Research Council 1995) notes that teachers need to respond to student diversity in ways that allow all their students to participate fully in science learning. In its ESL Standards for pre-K–12 Students, TESOL (the professional organization for teachers of English to speakers of other languages) includes goals for students that include the ability to “use appropriate learning strategies to construct and apply academic knowledge” and “to obtain, process, construct, and provide subject matter information in spoken and written form” (TESOL 1997, 91, 127). When science teachers write science literacy objectives for their science units and collaborate with the ESL
teacher, they are providing an exemplary standards-based learning experience for their ELLs.

Conclusion

Helping ELLs develop their science literacy skills gives ELLs the tools to engage in social interactions with other students in the classroom. As Long (1983) points out in his Interaction Hypothesis, when English language learners engage in collaborative conversation with native English speakers, they make attempts to maximize their comprehension. This social interaction with peers is important in developing English language proficiency, and it also helps ELLs further develop their science inquiry skills in a low-pressure environment with the help of their peers, building on what Vygotsky (1962) has called the social context of learning.

To be successful in the science classroom of the twenty-first century, all students need to be scientifically literate (Burkhardt et al. 2003). Creating science literacy objectives helps all students achieve this goal, especially ELLs who are still in the process of learning and developing their English and literacy skills. Science and language are interdependent because “each is based on processes and skills that are mirrored in the other” (Thier 2002/2003, 1). By bringing science and literacy together, science teachers help their ELLs develop the scientific literacy needed to engage in science learning and achieve academic success in the science classroom.

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