Chapter 8

Developing Academic Literacy

What Novice Teachers Can Learn from the Case of Teaching Latino/Bilingual Learners Science and Mathematics

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We believe that when teachers focus on developing students' academic literacy in the content areas, it contributes to strengthening the achievement of underrepresented minorities in the STEM field. This chapter will provide you with ideas to develop academic literacy through mathematics and science instruction.

It is important to keep in mind that each content area such as mathematics, science, social studies, arts, music, and others has its own particular way to use language to communicate meaning. This means that students need to become familiar with the *discourse* practices common to each discipline to be able to understand and communicate knowledge.

Let's think of a simple example. Very young children learn to use and read words such as *more, less, same, observation, data,* and *experiment*. These words are ubiquitous. We found them used across disciplines and contexts. Children, especially bilingual or multilingual children learning English, need multiple opportunities to learn the specific ways in which language is used across disciplines. This means that teachers need to help students understand the specific ways of listening, speaking, *reading*, and *writing* in different content areas.

In this chapter we define "academic literacy" and describe meaningful strategies for students to participate in varied ways of doing and talking mathematics and science. We focus on teaching situations that involve students who speak a language other than English at home or who can be identified as *bilingual learners*. The number of bilingual learners in the country's classrooms is growing. The National Center for Education Statistics (NCES, 2015) indicates that an estimated 4.4 million or 9.2 percent of students in

public schools are classified as English language learners (ELLs). Then, it is important that all teachers become familiar with strategies that foster academic literacy for all students but especially those who are learning content through a second language.

This chapter presents different strategies to develop academic literacy illustrated through vignettes from classroom instruction designed for Latino bilingual learners showing: (a) challenging K-2 mathematics instruction that fosters problem-solving and communication of mathematical thinking through multiple ways of representation, and (b) challenging three to five science instruction that *scaffolds* critical thinking through an integrated process of talking, reading, and writing about science.

In addition, in this chapter you will learn how the strategies described could be adapted for diverse populations to foster academic literacy development in science and mathematics, and we will highlight some tips to foster academic literacy across content areas. We will focus especially on understanding how teachers can use students' cultural and linguistic resources to support conceptual understandings across the curriculum.

THE LANGUAGE OF SCHOOL

To be successful and to fully participate in classroom activities all children need to acquire the "language of school," a complex type of English that includes a wide range of competencies. "As students develop competence in using every day, social English to interact, they must also acquire the *academic language* associated with each specific content area" (Egbert & Ernst-Slavit, 2010, p. 4).

Typically, academic language is associated almost exclusively with specific vocabulary that students need to learn to do well in the different content areas. However, academic language involves developing multiple competences at three levels: vocabulary or word level, grammar or sentence level, and discourse or text level.

UNDERSTANDING ACADEMIC LITERACY

Most teachers when thinking of literacy think of reading and writing. Recently, different authors have indicated that academic literacy involves reading and writing skills but also the abilities of listening, viewing, thinking, speaking, and expressing through multiple representational systems (Gottlieb & Ernest-Slavit, 2014; Short & Fitzsimmons, 2007). Academic literacy requires the development of advanced levels of proficiency in the

Table 8.1 Elements of Academic Language

Levels	*Definition*	*Examples*
Vocabulary/ Word Level	*General Academic Vocabulary*: Words used across content areas	Analyze, explain, contrast, compare similar, interconnected, reasoning, explanation
	Specialized Content Vocabulary: Terms associated and mostly used in specific content areas	Mathematics: hypotenuse, cardinal and ordinal numbers Science: photosynthesis, experiment, osmosis Language Arts: spelling, grammar. Social Studies: continents, latitude, altitude, democracy, constitution, amendment Music: overture, melody, tempo
	Signal Words: Used to establish connections between ideas	"because" or "consequently" identify cause-and-effect relationship "finally" and "first," indicate a sequence
Grammar/ Sentence Level	It relates to the syntax and the mechanics of writing sentences and paragraphs. Some features relate to specific content areas.	Mathematics: formulas, use of prepositions (divided by) Science: use of imperative in experiments instructions Social Studies: use of multiple forms of past tense
Discourse/ Text Level	Different types of text used across content areas	Mathematics: story problems, proofs Science: experiment instructions, science report, science journaling Social Studies: cartograms, folktales, historical documents Language Arts: autobiographies, novels, plays

Adapted from Freeman & Freeman (2009); Slavit & Ernst-Slavit (2007); Egbert & Ernst-Slavit (2010); Gottlieb & Ernst-Slavit (2014).

four *language domains*: reading, writing, listening and speaking and visual literacy skills (NGA & CCSSO, 2010).

Developing academic literacy also requires that students can understand and effectively use the specific forms of oral and written communication that vary from subject to subject. In addition, it comprises the knowledge of multiple *genres* of text, as well as purposes for text use. For instance, in science, students need to become familiar with how to write experiments' instructions; in social studies, students will write historical reports; and in music, students will become familiar with music notations.

Then, developing academic literacy involves students acquiring academic language in terms of specific vocabulary, types of sentence patterns used in different types of texts, and the characteristics of the texts or discourse associated with different subjects. Recently, changes in the way we communicate

through visual media make it essential for students to understand visual images in connection with accompanying text, as well as being able to visually represent different types of knowledge.

As students move through the elementary grades in school, they are asked to use language in increasingly more demanding ways. This language requirement puts bilingual learners at a disadvantage and, in the long run, diminishes their opportunities for academic success. To succeed in school *all* students need advanced levels of proficiency in the four language domains of reading, writing, listening, and speaking, as well as in viewing and visually representing knowledge. Teachers will need to develop strategies that support students' use of language in different situations, for varied purposes, and with different audiences (Egbert & Ernst-Slavit, 2010).

Understanding the language demands that learning content in a different language impose to children is a key tenet of an instructional approach that considers the cultural and linguistic differences that students bring to the classroom.

The concept of academic literacy was well summarized by the Adolescent English Language Learners Literacy Advisory Panel:

- Includes reading, writing, and oral discourse for school
- Varies from subject to subject
- Requires knowledge of multiple genres of text, purposes for text use, and text media
- Is influenced by students' literacies in contexts outside of school
- Is influenced by students' personal, social, and cultural experiences

(Short & Fitzsimmons, 2007, p. 8)

Tips on Academic Literacy in Lesson Planning

Think of a lesson you have planned or taught in a content area such as mathematics, science, and social studies and reflect back on the following questions:

- How was academic literacy addressed in your lesson?
- Did your lesson consider multiple ways of representing knowledge? How?

Based on what you have read so far about academic literacy, what could change in this lesson to better address academic literacy?

From this perspective, teaching across disciplines needs to emphasize the need for students to participate in literacy events contributing to the development of new knowledge, ways to challenge current practices, and the use of language for advance literacy practices (Schleppegrell & Colombi, 2002).

Following Conley (2012), we identify a series of principles to develop content area literacy:

- Create opportunities for collaboration through interdisciplinary curricular units of exploratory learning.
- Provide students with multiple opportunities for practice for listening, speaking, reading, writing, interpreting visual media, and visually representing text.
- Focus student attention on words and patterns as they read and write about or discuss the content they are learning.
- Teach students to become critical thinkers by evaluating each other's contributions about a particular content or evidence presented on their investigations.

UNDERSTANDING THE LANGUAGE DEMANDS OF CONTENT LEARNING

Learning academic literacy occurs when teachers design instructional strategies that provide students with multiple and varied opportunities to participate in ways of doing and communicating knowledge in the content areas and to share new knowledge through multiple ways of representation (Schleppegrell, 2004). The *language demands* of learning in the content areas are typically invisible for mainstream teachers, especially for teachers teaching content in middle or high school because they are not used to see language as content of instruction (Harper & de Jong, 2004).

Let's think about an example. Helen, a novice third grade teacher, has learned that using a K-W-L chart is a "good" teaching practice. She has planned to use the K-W-L chart during her social studies lesson to guide students through a reading about the basic structure of government in the local community, state, and nation, while making connections to their previous knowledge on the topic. Being aware of the language demands that this task entails, she needs to consider the language skills that bilingual students need to effectively participate in the activity. With this in mind, she asks questions to scaffold student's brainstorming of ideas and language use:

What I *K*now
- Tell me everything you know about _____.
- What made you think of that?

What I *W*ant to Know
- What do you want to learn about this topic?

- What do you think you will learn about this topic from the text you will be reading?
- What would you like to learn more about idea X?

What I *L*earned
- Students answer the questions in the W section.
- Students list interested facts they found.
- Students consult other resources to answer the questions they did not find in the text.

To complete and interpret these questions, students need skills that will enable them to identify and state facts and propose ideas and ask questions (Harper & de Jong, 2004). These tasks could be very cognitively demanding for students who are learning content in a second language. It is important that instructional activities in the different content areas make explicit the different reading and writing demands and discourse conventions of the disciplinary domains (Schleppegrell, 2004).

Tips on K-W-L Implementation

Consider a situation where you are teaching the concept of extreme weather conditions:

- Select a reading to introduce the concept and build background knowledge of your students using a K-W-L chart.
- Using similar questions like the ones presented in the previous example, complete the K and W part of the chart with your students.
- Consider the language demands of the selected reading, and on the basis of your assessment, decide on the vocabulary that you will have to front-load to make the reading event accessible to all learners in the class.
- Think of a strategy that you can use to introduce the vocabulary.
- Read the text, discuss it with students, and ask them to complete the L part of the chart in groups on the basis of the information gathered from the book.
- Reflect: In what ways did the strategic use of the scaffold support your students' access to the content and facilitate their language use?

The content areas or disciplines are social constructions that involve particular ways of representing and communicating knowledge using distinct discourses and different levels of *linguistic complexity*. As an example, despite the extended belief that mathematics is a universal language, some mathematical ideas are represented differently in different countries. For instance,

the procedures taught in the United States for the long-division algorithm might be very different from those that students learn in schools in their home countries.

Promoting Literacy through Challenging K-2 Mathematics Instruction

Communicating mathematically and making sense of mathematics problems could be challenging for young children, particularly children who are in the process of learning the language of instruction. To help students develop mathematics academic literacy, teachers need to see language and mathematics as jointly constructed and not separate. Developing mathematics vocabulary either in English or in the students' first language is important. However, effective practices should be anchored in a more complex understanding of literacy and focus instruction on providing multiple opportunities to listen, develop, and communicate orally and in writing mathematics reasoning and not just vocabulary development (Moschkovich, 2007). To achieve this, teachers at all grade levels can develop strategies to

- use *language as a pedagogical resource* by building on students' bilingual language skills;
- promote challenging problem-solving and communication of mathematical thinking through multiple ways of representation (modeling, drawing, using symbols, writing, oral explanations); and
- explicitly teach the language of mathematics, semantic reasoning, and the specific symbols.

Bilingual learners come to school with a wide range of linguistic resources. When learning mathematics or other content areas, bilingual learners not only use their English and home language skills, but also draw from both sets of social and academic languages. When designing mathematics instruction that values communication, teachers must consider bilingual learners' language skills and foster participation in both "everyday" and "mathematical" interactions (Moschkovich, 2007; Slavit & Ernst-Slavit, 2007). There are ways of saying and communicating ideas in mathematics that are influenced by culture and language.

Tips on Student Language

Observe and reflect on student language resources and teacher instructional strategies during a mathematics lesson. You can observe a peer or watch a video of a lesson online. Mathematics lessons' videos can be found at http://www.insidemathematics.org. While observing a lesson:

- Identify instances when students use their home language to communicate mathematically.

Does the teacher use strategies such as questioning to ask for clarification, building on student responses and revoicing student's explanations. Mathematics learning requires the development of academic literacy skills that help to contextualize content meaning making designing activities that take into consideration students' language and culture (Celedón-Pattichis & Musanti, 2013). For instance, when teaching mathematics teachers can design word problems that connect students' familiar practice of storytelling in their native language to mathematics problem-solving (Turner, Celedón-Pattichis, Marshall, & Tennison, 2009).

The following vignette illustrates how Analía, a second grade teacher in a bilingual classroom, presents students with a challenging partitive division mathematics problem. Analía has noticed that several students in her classroom struggle to understand the structure of some mathematics problems, and they have difficulties identifying relevant information to use while solving the problem. Her objectives for this lesson were to work on more effective ways to solve this type of problems and to model how to interpret the language of the problems providing tools to support students' semantic reasoning.

For this lesson, Analía purposefully selected a problem that involves a multiple of 5 to encourage grouping by fives. Yesica had 45 cookies. She is going to share them with 8 friends. How many cookies does each girl get? After writing the problem on the board, teacher and students read the problem as a whole group.

TEACHER: Raise your hand. First, what information is important to solve the problem? What information is important and necessary to know to find the answer?

STUDENT 1: Yesica had 45 cookies

TEACHER: Good [underlining the information in the problem]. What else is important?

STUDENT 2: How many cookies does each girl get?

TEACHER: The question! [Teacher underlines the problem question on the board.]

TEACHER: [Turns to face students] What else is important? Can we solve this problem with this information?

STUDENTS: Nooo!!!!

TEACHER: Another piece of information is missing.... We need more information. What is it?

[Several students raise their hands. Teacher chooses one student.]

STUDENT 3: Share with 8 friends

TEACHER: What does it mean "she will share with 8 friends"?

STUDENT 1: That Yesica is going to count that she is going to have cookies.

TEACHER: Is that right? Then how many girls are there in total?

STUDENTS: Nine!!!!

TEACHER: Yes, nine. Now do we have all the information we need?

STUDENTS: Yes!!

TEACHER: Now, you can think with your group what is the fastest way to find the answer.... We already know how to count by two´s, five´s, ten´s.... Think with your group how you can find the answer and what is the fastest way. Represent in your poster how you did it.

To solve this problem, students need to identify key information and to infer that they need to divide 45 between 9 girls. The problem implies that Yesica will get cookies too. This problem might challenge all students, but it could be particularly difficult for bilingual students who are still not familiar with the specific ways to use language in mathematics, that is, the mathematics discourse. In this case, the language demand requires them to interpret the idea of "sharing" as involving Yesica. This lesson shows how important it is to scaffold the use of language that students need to tackle challenging mathematics problems. The vignette shows three important ways in which this teacher is promoting mathematics academic literacy.

First, the teacher asked students to identify important and necessary information to solve the problem. This is an important skill that requires students to make sense of the word problem. The narrative structure of problem scaffolds students' thinking and provides the clues to identify essential information. Analía modeled the process writing on the board what students identified as relevant information using different ways to represent the information with symbols and in writing.

Second, the teacher helped students to make sense of mathematics language. For instance, she asked them to explain the mathematics meaning embedded in the sentence, "She will share the cookies with 8 friends." A common mistake students made was to identify the numbers in the problem without consideration to the text and how the meaning changed that numeric value.

Third, the teacher challenged students to compare different ways to solve this problem, asking them to find the fastest strategy. This is an important

problem-solving skill that all students need to develop. To support this process Analía asked students to represent and explain the different ways by which they could solve the problem and compare the strategies in terms of efficiency.

For instance, students were able to identify that as there were 45 cookies and 9 girls, Yesica could distribute 5 to each until she ran out. Analía asked them to demonstrate this strategy to prove if it would work using different ways to represent their solution. She encouraged students to work in groups and come up with at least two different ways to show how they solved the problem, either by drawing their solution, using numbers and algorithms, or by writing their explanation.

The use of multiple ways to represent problem-solving strategies is an important skill that students need to develop. After solving the problem, each group shared the different ways they used to solve the problems with the whole class. Students were asked to explain the solution. To scaffold oral communication of mathematics thinking, teachers can use different types of questioning to

- make sense of the problem: ask questions to help students retell the problem or describe the problem in their own words and to identify important information.
- demonstrate or probe how they solved the problem and explain their reasoning: ask questions to explain how they reach a solution or describe a strategy. Would you explain to me how you figured this out? How did you count? Why? Which way of solving this problem is faster?

An important practice to develop academic literacy requires the implementation of strategies that promote teachers' and students' mathematics talk using multiple ways to communicate students' thinking and problem-solving strategies (Chapin, O'Connor, & Anderson, 2009).

Tips on Closing the Math Achievement Gap

Go to Closing the Math Achievement Gap site: http://www.uwosh.edu/coehs/cmagproject/cogn/word_prob.htm

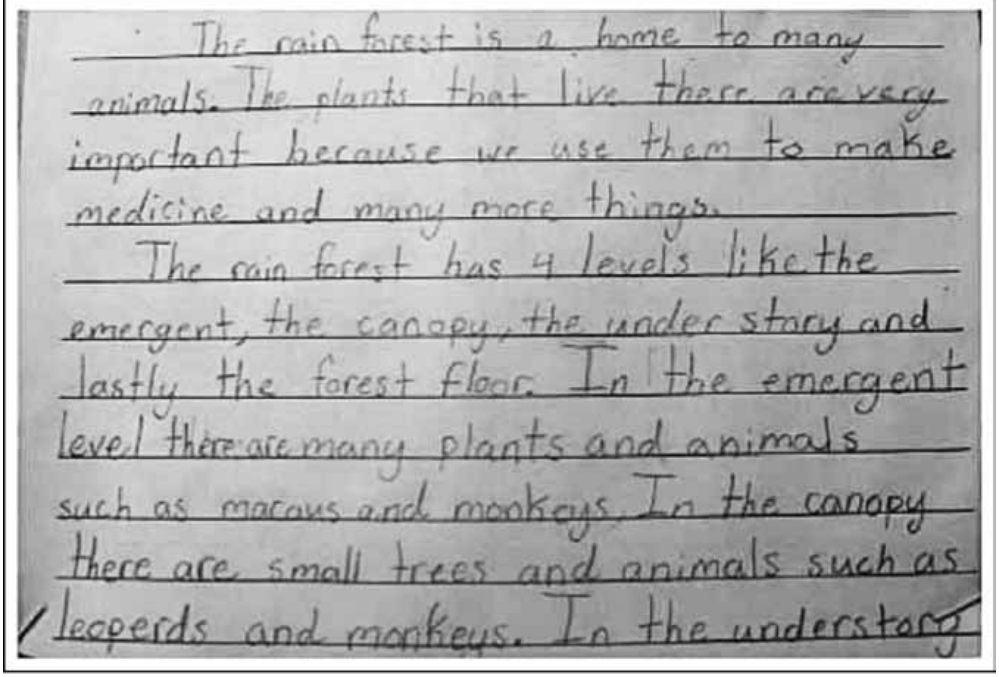
- Explore the word problem examples for the grade level you are teaching or you would like to teach. Compare and contrast with the word problems in the mathematics curriculum you are using or a teacher you have observed is using.
- Try to identify similarities and differences.
- Choose a type of problem and write examples of problems that integrate your knowledge of your students' cultural background.

Promoting Academic Literacy through Challenging Three to Five Science Instruction

As we explained above, the type of academic literacy that is required for school-related tasks involves not only the development of listening, speaking, reading, and writing skills, but also the development of more abstract and demanding language. For example, the academic language of science uses technical words and complex grammatical structures with a high density of information that makes the reading of science text challenging for all students and, more in particular, for bilingual learners (Snow, 2010). It is important that teachers design instruction to help bilingual students learn the content knowledge and the academic language of science—including critical thinking—through an integrated process of talking, reading, and writing about science (Mercuri, 2010; Lee, 2005).

The following text sample is from a third grade bilingual learner. The sample is about the rainforest. In groups or with a partner:

- First, identify what type of text the sample is based on the different type of science genres described above.
- Second, discuss the academic language features used by the student.
- Lastly, provide a series of strategies or steps you could use to further develop the student's writing of the sample provided.


The rain forest is a home to many animals. The plants that live there are very important because we use them to make medicine and many more things.

The rain forest has 4 levels like the emergent, the canopy, the under story and lastly the forest floor. In the emergent level there are many plants and animals such as macaus and monkeys. In the canopy there are small trees and animals such as leaperds and monkeys. In the understory

Figure 8.1 Text Sample.

One way to provide opportunities for the development of *scientific literacy* while creating opportunities for exploration is to plan *interdisciplinary units of inquiry* (Freeman, Freeman, & Mercuri, 2005). These units of inquiry are guided by an essential question and integrate literacy throughout including activities for students to read and write different types of texts. For example, Freeman and Freeman (2009) explain that there are different genres in science for students to read or write:

- Procedural text: reading and writing instructions for an experiment. Students use the imperative tense.
- Procedural recount: recording and describing what has been done in an experiment. Students use the past tense.
- Science report: organizing information by dividing a phenomenon into its parts or steps or by listing its properties. Students use the present tense.
- Scientific explanation: describing how and why a scientific phenomenon occurs, dealing with interactions of factors and processes rather than a sequence of events.

Working with bilingual learners through these different types of texts presents a challenge for teachers today. Students have to access academic content through their second language while they are still developing that language (Short & Fitzsimmons, 2007). Research has shown that students' first language should be used to support content understanding in their second language and to facilitate the transfer of language skills. One approach to using students' first language as a pedagogical resource is by designing instruction that integrates strategies such as *Preview/View/Review* (P/V/R) (Mercuri, 2015). When using this strategy, the teacher usually starts by introducing the topic in students' first language, then develops the lesson content in the main language of instruction, and finalizes the lesson with a review of the main ideas or an integration of ideas in students' first language.

For instance, in a third grade interdisciplinary unit on ecosystems, María starts by introducing the topic by reading the book *Dentro de la selva tropical* (Inside the Rainforest) by Willow and Jakes (1993). This activity contributes to enhancing students' understanding about the topic of the lesson and also to enriching their academic vocabulary in Spanish through the descriptive language used throughout the book.

In her research synthesis on ELLs and science education, Okhee Lee (2005) explains that "subject area instruction should provide a meaningful context for English language and literacy development, while advancing English skills provides the medium for engagement with academic content" (p. 492). An important aspect of developing the language of science is a focus

Table 8.2

When planning your next unit of inquiry, use the following table to identify key academic vocabulary

Type of Vocabulary	*Definition*	*Examples*
General Academic Vocabulary	Words used across content areas	Analyze, explain, contrast, similar
Specialized Content Vocabulary	Terms associated and mostly used in specific content areas	Mathematics: hypotenuse Science: photosynthesis
Signal Words	Words that establish different type of connections or relationships between ideas	"because" or "consequently" identify cause-and-effect relationship "finally" and "first" indicate a sequence

Source: Adapted from Freeman & Freeman (2009) and Slavit & Ernst-Slavit (2007).

on words and sentence patterns as they read and write about or discuss the content that they are learning (Conley, 2012).

The following vignette illustrates how Natalia, a fifth grade teacher in a border town of Texas, creates opportunities for students to develop science content knowledge and academic language through effective academic literacy practices when teaching the steps of the scientific methods.

TEACHER: What is your experiment about?

STUDENT 1: It's about slime

STUDENT 2: Our independent variables are the types of glue, our dependent variable is the slime effect we will create.

STUDENT 1: Our hypothesis is if we use Elmer's glue then it will create a slimier effect because it's denser than the other HEB glue we will use... and our procedure is...

STUDENT 2: Okay... first we put the glue in the container and mix it... well, first we put a tablespoon in the container and second one tablespoon of borax in the same container, third red food coloring in the same container and then we dissolve it with water...

STUDENT 1: We dissolve it with 10 ml of water and then we mix them, and finally slime should start to form.

TEACHER: Great... show me the results... what happened?

STUDENT 2: This one... (pointing at the first container) was the clear HEB glue... and it came out more compact...

TEACHER: And the other container?

STUDENT 1: The other one looks like gum, you can stretch it more, look... (pointing at the second container).

TEACHER: Then, was your hypothesis correct?

STUDENT 1 and 2: Yes. The Elmer's glue creates a slimier effect.

This vignette shows students' use of academic language to explain the experiment and their findings. Students use specific science vocabulary, general academic terms, and signal words to describe the experiment, which shows their academic language development (Freeman & Freeman, 2009; Gottlieb & Ernest-Slavit, 2014). For example, students use content-specific vocabulary such as *dependent, independent variables*, and *slime effect.*

In addition, the students are using general academic terms that appear across different content areas. Some of those terms are *experiment, hypothesis, procedure, dissolve*, and *compact* and are not commonly used by bilingual learners in everyday language. Students are using signal words to explain the procedure to justify their claims (i.e., *first, second, third, then,* and *finally*), and to construct sentences traditionally used in scientific discourse to present hypothesis. For example: "Our hypothesis is *if* we use Elmer's glue *then* it will create a slimier effect because it's denser than the other HEB glue we will use."

Tips on Designing Activities for Lesson Review

On the basis of the lesson that Ms. Huarte taught about the rainforest described above, consider strategies for checking for understanding and language use such as:

- Completing the L part of a K-W-L charts on the topic of study
- Using an oral exit ticket on a concept to provide clarification
- Doing a whole class picture match activity to check for understanding
- Using a soft ball for "wonder questions" about a topic
- Using the games "*Simon Says*" or "*I have, Who has*" to practice academic vocabulary.

Design a short activity for the review segment of the lesson. Keep in mind that the activity should be a checking for comprehension of what the students have learned during the lesson in English. After designing the activity consider the following questions:

1. How does the activity integrate the content students learned and the language development of skills that students are working on?
2. Does the activity consider linguistic differentiations according to students' different language proficiencies?

The way they integrate the vocabulary to support their explanations of the experiment results demonstrates both conceptual understanding and academic language development. In addition, the interaction between teacher and students is an example of scaffolded instruction that focuses on students' productive participation in scientific practices and discourse to support the development of scientific literacy (Zembal-Saul, McNeill, & Hershberger, 2013).

As seen in the vignette, science provides a context for the meaningful learning of language structures and functions, and these linguistic processes become the medium for analysis and communication of scientific knowledge. Language and content knowledge build on each other and support the development of scientific literacy.

ACADEMIC LITERACY AS AN INTERDISCIPLINARY APPROACH

All teachers, Analía, Maria, and Natalia, apply their understanding of academic literacy to other content areas. All plan instruction through interdisciplinary units, identifying themes and developing lessons in different content areas that contribute to the understanding of the overall topic while developing proficiency in the different language domains. For instance, María designed a culminating activity for the unit on the tropical forest so students could integrate and demonstrate the knowledge gained through an art project.

For this project María expected their students to visually represent their understanding using geometric figures to create the different layers of the tropical forest, including animals and plants. In addition, students needed to present their art projects giving them the opportunity to practice their oral language skills to interpret visual images as well as text, and to further develop their speaking abilities.

She designed this project so that all students, no matter what their English *language proficiency* is, could express their understandings through different ways of representing knowledge. She knows that this is an excellent opportunity to develop academic literacy through art forms, integrating students' first language and cultural knowledge.

Tips on Developing Unit Projects

- Develop a culminating project for a unit that you have taught or plan to teach.
- Include in the project an aspect of social studies, art, or math that you want your students to present to demonstrate the knowledge gained through the unit.

- Develop a handout that provides examples for students to demonstrate the connections they can make across content areas and topics.
- Identify in the handout what the students will do to further develop their four language domains: listening, speaking, reading, and writing.

SELF-REFLECTION

Reflect back on what you consider was an effective mathematics or science lesson you planned and taught. Try to identify two reasons why you consider this lesson successful and write them down.

a. To complete this reflective exercise, now, make a mental picture of the classroom, the different groups of students, and what you know about these students in terms of language diversity and cultural diversity. Ask yourself questions, such as:
   - What did you notice in relation to students' cultural diversity?
   - What did you notice in relation to students' language diversity?
   - What did you notice in terms of students' language resources (social language skills, academic language skills, first-language use, second-language use)?
   - What did you notice in terms of students' literacy experiences?
b. Now it is time to look back at the reasons you have identified as critical for a good mathematics or science lesson and consider how they relate to what you have noticed about your students' culture, language, and literacy experiences.
   - How could you integrate this knowledge in your lesson planning?
   - What specific changes in terms of activities, content, and language support will you apply to this lesson?
   - How will these changes improve students' content understanding and academic literacy development?

While answering these questions you might want to consider the following checklist to develop academic literacy across content areas.

CHECKLIST TO ADVANCE ACADEMIC LITERACY ACROSS CONTENT AREAS

To make sure you are including strategies that foster academic literacy development in the different content areas, use the checklist shown in Figure 8.2.

1. I design instruction through units of inquiry to promote more contextualized and exploratory learning. Yes_____ No _____

2. I include activities to scaffold understanding of basic and complex concepts of the different content areas. Yes_____ No _____

3. I consider the language demands of the content in relation to my students' language proficiency. Yes_____ No _____

4. I consider the cultural and linguistic resources that my students bring to the classroom. Yes_____ No _____

5. I include activities that foster collaboration and interaction between teacher and students, and students and students. Yes_____ No _____

6. Students have meaningful opportunities to communicate their reasoning both orally and in writing. Yes_____ No _____

7. Student have multiple opportunities to represent their understanding through different media (print, visual, interactional, & electronic). Yes_____ No _____

8. Students have opportunities to develop and use academic language (words, sentence patterns, and different types of text). Yes_____ No _____

9. Students are encouraged to use their first language when needed as a resource for learning. Yes_____ No _____

Figure 8.2

CONCLUSION

To close the achievement gap that exists among underrepresented minorities such as Latinos, African American, and Native American students, we need instruction that advances the development of academic literacy across content areas. To be successful, all students need to develop the language of school, that is, the *social language*, to communicate effectively with others and the academic language that includes the vocabulary, syntax, and discourse styles of particular content areas. The chapter highlights the importance of understanding that academic literacy is much more than reading and writing, and we redefined it as integrating four language domains (listening, speaking, reading, and writing) as well as literacy skill to interpret and generate visual representations such as images and graphics.

This chapter provides with a concrete example to design mathematics instruction in K-2 settings, including challenging problem-solving that foster academic literacy by drawing on students' first language skills, developing students' skills to use multiple ways to represent solutions, and promoting

mathematics talk. The chapter also shows how to plan science lessons around interdisciplinary units to develop academic literacy while integrating the process of talking, reading, and writing about science and developing students' academic vocabulary and knowledge of different science texts (i.e., how to write hypotheses or the steps of an experiment).

Finally, this chapter provides important ideas to develop academic literacy across content areas. It is important to remember that to contribute to academic development teachers need to consider a variety of factors such as student prior knowledge, the ability to read and use vocabulary for different purposes, the language demands of each task, the linguistic complexity of the reading materials, and the nature and complexity of what the students are expected to do, say, or write. Specifically, we highlight the importance of integrating students' cultural and language resources and previous literacy experiences through instructional approaches such as teaching through interdisciplinary units of inquiry.

In addition, whenever possible, teachers should integrate strategies that tap into students' first language as a resource for learning. For instance, they should use strategies such as Preview/View/Review, presenting content in students' first language to build on students' linguistic competence and background knowledge. Finally, it is important to be aware of the language demands that learning content can impose on bilingual learners and to generate scaffolding strategies that promote multiple opportunities for students to represent and share their understanding both orally and in writing using different media (drawings, symbols, interactions, and text).

APPENDIX 1: EXTENSION MATERIALS

Building a Discourse Community in the Classroom

Bilingual learners need multiple opportunities to participate in meaningful mathematics and science conversations. Some authors have argued that teachers need to create discourse communities in their classroom, where students can actively participate in sharing and producing mathematical knowledge. To achieve this, teachers need to implement strategies to facilitate classroom discussions. These are some sources with valuable examples and tips:

- *Talking the Talk: Tips for Engaging Your Students in Scientific Discourse*: TeachingChannel.org offers this blog authored by Alissa Berg that addresses key instructional points from the Next Generation Science Standards (NGSS). "This blog briefly explains the difference

between traditional classrooms talk and 'productive talk' and includes tools and strategies for generating and facilitating the latter in your classroom." Available at: https://www.teachingchannel.org/blog/ausl/2014/04/21/talking-the-talk-tips-for-engaging-your-students-in-scientific-discourse/.

- *Math Solutions* website: The site has several videos and free resources that illustrate lessons that foster math talk.
  - *What does academically productive talk look like?* This is a blog entry that defines math talk as a strategy to promote deeper learning and provides tips to implement it in the classroom. http://mathsolutions.com/free-resources/what-does-academically-productive-talk-look-like/.
  - *"Math Talk in Action—First Grader"* (A first grade teacher in a two-way bilingual school helps her students listen to and repeat a classmate's thinking): http://mathsolutions.wistia.com/medias/09lyt1vbry.

Teaching for Scientific Literacy

Developing scientific literacy is critical for individual and social growth. The Next Generation Science Standards (NGSS, 2014) state that literacy development is critical to construct science knowledge. "Any education in science and engineering needs to develop students' ability to read and produce domain-specific text. As such, every science or engineering lesson is in part a language lesson, particularly reading and producing the genres of texts that are intrinsic to science and engineering" (NRC *Framework*, 2012, p. 76).

- Project 2061 is a long-term research and development initiative focused on improving science education so that all Americans can become literate in science, mathematics, and technology. This project is sponsored by the American Association for the Advancement of Science (AAAS). We encourage you to explore this site and the publications, research, and teaching materials they have developed. For instance, you will find the *Atlas of Science Literacy* with conceptual strand maps—and commentary on those maps—that show how students' understanding of the ideas and skills that lead to literacy in science, mathematics, and technology might develop from kindergarten through twelfth grade. http://www.aaas.org/program/project2061.
- The National Science Teacher Association (NSTA) has a series of books and resources that will support teachers at all grade levels in the teaching of science. Some of those resources are free. Check the link below for free resources from the NSTA. https://www.nsta.org/publications/freebies.aspx.

Articles, Books, and Websites

- K-5 Mathematics Teaching Resources: This site provides an extensive collection of free resources, math games, and hands-on math activities aligned with the Common Core State Standards for Mathematics: http://www.k-5mathteaching resources.com.
- You can find interesting examples and lesson materials such as a virtual mathematics word wall in many different languages at: *The Algorithm Collection Project*—a website developed by Daniel Clark Orey, PhD professor emeritus, California State University, Sacramento: http://www.csus.edu/indiv/o/oreyd/ACP.htm_files/Alg.html.
- Books to enhance teachers' understanding of how to teach for scientific literacy:

  Zembal-Saul, C., McNeill, K., & Hershberger, K. (2013) *What's your evidence? Engaging K-5 students in constructing explanations in science.* Upper Saddle River, NJ: Pearson Education.

  Thier, M., & Daviss, B. (2002). *The new science literacy: Using language skills to help students learn science.* Portsmouth, NH: Heinemann.

  Grant, M., & Fisher, D. (2010). *Reading and Writing in science: Tools to develop disciplinary literacy*. Thousand Oaks, CA: Corwin Press.

Videos

These are some videos available online that provide valuable ideas on how to develop literacy across the content areas.

Literacy across the curriculum: This video demonstrates how literacy is part of all aspects of school life. https://www.youtube.com/watch?v=R088edAQYzc.

Academic literacy in mathematics education: This video shows an example of how a teacher supports literacy development through mathematics teaching in a third grade classroom. https://www.youtube.com/watch?v=sCpDXuoNpTQ&index=1&list=PLdhfCYg5nUa1-v_EJSwk-pA2dRSA3blRh.

A Focus on Math: Áhi'iltaa*, Math in Cultural Context*: This short film illustrates the use of Dine' (Navajo) Language and Culture in the math curriculum in the STAR School 3-to-3rd project. This is the second in a series of three short films demonstrating how and why the STAR School's 3-to-3rd (age 3 to grade 3) project focuses on math. STAR is located on the southwestern edge of the Navajo Nation and serves a majority indigenous population. Available at: https://www.youtube.com/watch?v=nQCItldgzw0.

What is science literacy? This video shows the importance of developing critical thinking and science literacy. https://www.youtube.com/watch?v=BaM662xrlp8.

Exploring STEM concepts with younger students. This video was produced by Dr. Diana Wehrell-Grabowski. It shows how young children learn about STEM concepts, communication skills, and collaboration while building with blocks. In addition, teachers and students were introduced to numerous children's literature that reinforces STEM concepts. https://www.youtube.com/watch?v=HglYz0h2n2E.

GLOSSARY OF TERMS

Academic language—academic language is the language used to learn at schools and to develop knowledge in different disciplines. It includes a range of competences to process and produce meaning across language domains (listening, speaking, reading, and writing) and specific linguistic traits of each discipline including types of texts or discourse, grammatical features, and specific vocabulary. Academic language is produced in a specific sociocultural context. We use academic language to acquire new understandings and skills, to develop knowledge, and to communicate knowledge to others (Slavit & Ernst-Slavit, 2007).

Bilingual learners—recently, authors such as García and Kleifgen (2010) have raised important questions over the labeling of students as English language learners. Specifically, they argue that English language learners are in fact "emergent bilinguals." This means that they become bilingual throughout their schooling experience and as they acquire English, communicating and interacting using their home language as well as English to make sense of the world and to learn. In this chapter, we prefer to identify students in this situation as bilingual learners to be inclusive of the wide range of experiences and development of bilingual skills.

Discourse—the different ways in which we use language to convey multiple connected ideas in a way that is specific to different fields of culturally and historically located meanings. "Discourse is most simply understood today as a sort of unit of language organized around a particular subject matter and meaning." For an enhanced explanation, see: http://csmt.uchicago.edu/glossary2004/discourse.htm

Genre—the Merriam-Webster dictionary defines "genre" as "a category of artistic, musical, or literary composition characterized by a particular style, form, or content." That is the socially defined ways in which different types of texts are used to participate in particular contexts to serve specific purposes (WIDA Consortium, 2012). Text genres vary across disciplines and could include written or oral text. For instance, social studies and science are characterized for the predominance of expository (informational) texts, and fiction texts are typical in language arts and literature. Examples of

genres are journals, biographies, poetry, picture books, textbook, novel, science article, dialogue script, debate, and many more.

Interdisciplinary units of inquiry—when planning interdisciplinary units, the subject areas are connected. Interdisciplinary thematic units are organized around big or essential questions that provide integration between the different themes and help to connect with students' lives and experiences. Students learning in different subject matters will connect to this big topic and help them answer the big question. This approach also provides more meaningful opportunities to learn academic language (Freeman, Freeman, & Mercuri, 2005).

Language as pedagogical resource—students language/s are a resource for learning. Students access, construct, and communicate knowledge through language. This is especially important for bilingual learners who are still developing their second language. Understanding students' first language as a legitimate and necessary resource for learning is a step toward designing instruction that provides the best access to conceptual understanding (Musanti & Celedón-Pattichis, 2012).

Language demands—language demands relate to the complexity and variations of academic language across disciplines and the cognitive challenges it imposes on students to understand the content. When considering the language demands of a learning task, teachers need to pay attention to the receptive language skills (e.g., listening, reading) or the productive language skills (e.g., speaking, writing) that the students need to engage in and complete the task. Each content area might involve different language demands in terms of specific or technical vocabulary, grammatical features, the use of symbols, constructing explanations, critiquing reasoning of others, asking questions, identifying problems, and accessing different types of texts, among others.

Language domains—language includes different modalities related to the receptive function (listening and reading) and expressive function (speaking and writing).

Language proficiency—students' abilities to process language (through listening and reading) and to produce (through speaking and writing) language.

Linguistic complexity—"The organization, cohesion, and relationship between ideas expressed in the variety and kinds of sentences that make up different genres and text types in oral or written language at the discourse level" (WIDA Consortium, 2012, p. 114).

Preview/view/review—preview/view/review allows teachers to make the second language more comprehensible by giving an introduction, or preview, in the students' first language, then teaching the content in the second language using a number of techniques to make the input comprehensible,

and finally reviewing after the lesson in the students' first languages (Freeman, Freeman, & Mercuri, 2005; Mercuri, 2015).

Reading—reading is a complex process that involves making meaning from print.

Scaffolding—scaffolding refers to teaching that provides the support to build on students' previous experiences, skills, and knowledge through the use of strategies such as simplified language, teacher modeling, use of visuals and graphics, and hands-on learning to foster language development and student learning (WIDA Consortium, 2012).

Scientific literacy—is defined as the knowledge of science content and processes with an added ability to articulate and communicate inquiry procedures and science understandings orally and in writing. This definition of scientific literacy includes two abilities central to the development of scientific literacy: producing scientific explanations and argumentation both orally and in writing (Zembal-Saul, McNeill, & Hershberger, 2013).

Social language—the everyday language use in interactions outside and inside school (WIDA Consortium, 2012).

Writing—writing is a form of communication that allows students to express ideas, events, and feelings, and to convey meaning through print.

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