PROGRAM RESEARCH BASE

CONTENT ESSENTIALS™ *for* SCIENCE

Vocabulary • Content • Literacy

McGraw Hill Wright Group

Contents

Executive Summary

Content Essentials™ for Science is designed to help all students, especially English Language Learners (ELLs), learn content through language and vocabulary practice. *Content Essentials for Science* targets students who need background knowledge, concept building, and the vocabulary to comprehend and explain science concepts as well as the inquiry-based learning that is part of studying science. The main goal of *Content Essentials for Science* is to help all students develop the vocabulary and language they need to be successful content-area readers.

There is a strong emphasis on academic vocabulary that is taught through context by:

- Preteaching key concepts and vocabulary; building background knowledge and language prior to whole-class lesson/textbook usage
- Reteaching key concepts and vocabulary after the whole-class lesson or textbook usage
- Explicit instruction in nonfiction reading strategies, including comprehension, text features and structures, and genres (e.g., how to read science books)
- Explicit instruction in understanding language, including word study (e.g., prefixes and suffixes) and language use (e.g., multiple-meaning words, homophones)
- Explicit instruction in content-driven writing (forms, research, reports)

The *Content Essentials for Science* program provides explicit strategy instruction through practical, replicable, and proven techniques. This instruction is effective as a routine part of English language development and reading within science. Part 1: Science Essentials focuses on the academic vocabulary and concepts needed to make science content comprehensible. Part 2: Literacy Essentials provides explicit strategy instruction for reading science, comprehension, understanding language, and writing for science.

Content Essentials for Science provides language development for all students, but it is especially beneficial for ELLs. With explicit strategies and instruction, teachers can teach vocabulary effectively to ELLs. However, the linguistic and cognitive challenges of academic language for ELLs can be overwhelming when language, reading, and content are taught separately. This paper explains and provides the research foundation for how language, literacy, and knowledge accelerate when they are integrated and a large chunk of instructional time is given to vocabulary development (Calderón 2007a and 2007b). *Content Essentials for Science* builds on this and other research and employs a comprehensive system for addressing each challenge.

Calderón, M. E. 2007a. *RIGOR! Reading instructional goals for older readers: Reading program for 6th – 12th students with interrupted formal education.* New York: Benchmark Education.

Calderón, M. E., 2007b. *Teaching reading to English language learners, Grades 6–12: A framework for improving achievement in the content areas.* Thousand Oaks, CA: Corwin Press.

Learning Language through Science

Program Research Base for *Content Essentials for Science*

Margarita Calderón, Ph.D.

Science can be an exciting course of study; however, many students, including English Language Learners (ELLs), need to be able to understand the language in order to access the content and learn the concepts. Students whose first language is not English face a daunting task when it comes to learning subject matter if they do not know many of the words they are hearing or reading. The added difficulty of learning science is that it has its own language and specialized vocabulary. The language of science has a much more specific meaning than the everyday use of words. For example, the words needed to discuss *movement* specific to the muscular system or nervous system and the sentence structures on which they are nested will be very different from those used in a story about a student moving to another city.

It is important for students to understand how language is used in science because the relationship between language proficiency and achievement in science content acquisition is strong; the ways in which students are tested are dependent upon their vocabulary and literacy proficiency (National Panel on Literacy for Adolescent English Language Learners 2006; Slavin and Madden 2001; Calderón et al. 2005). In addition, teachers often rely on content information from textbooks for their instruction. However, students who have difficulty with essential literacy skills often have problems keeping up with classroom science instruction. Because they have difficulty decoding and comprehending text, students are often denied access to ideas and conceptual understanding.

Another factor that distinguishes the language-based learning that must take place in science is that it is socially constructed through discourse and interactions with others. Many studies have found a consistent relationship between reform practices (hands-on, inquiry, discovery, experiential, project-based or constructivist) and improved learning, when compared to students in more transmissive or traditional classrooms (National Research Council 1996). Students need the vocabulary to engage in this type of learning.

In addition, science requires application of scientific inquiry skills. The cognitive abilities of scientific inquiry go beyond what have been termed science "process skills such as observation, inference and experimentation" (National Research Council 1996). Inquiry abilities require students to mesh these processes with scientific knowledge as they use scientific reasoning and critical thinking to develop their understanding

of science (National Research Council 1996, 18). Students need to discuss questions, such as, "What counts? What data do we keep? What patterns exist in the data? What explanations account for the patterns? Is one explanation better than another?" The question we must ask is, "Are English Language Learners being kept out of the inquiry process because they do not have the words to ask or discuss these questions?"

Why is Vocabulary Important?

Word knowledge correlates with comprehension (Beck et al. 2002; Samuels 2002; Juel 1988; Nagy and Anderson 1984). Comprehension correlates with test results (Calderón 2007b).

For ELLs and other striving readers, the vocabulary in the books they read affects whether and how they achieve fluency and comprehension (Menon and Hiebert 2003). In other words, the size of a student's vocabulary bank predicts his or her level of reading comprehension. In today's No Child Left Behind terms, it means that the number of words known also predicts how students perform on high-stakes tests that call for any type of reading comprehension. Unless a student knows 85 to 95 percent of the words he or she is reading, comprehension will be stifled (Samuels 2002).

Developing knowledge of science requires that students learn to use language and literacy in ways that are very different from their English as a second language and/or language arts classes. These classes often focus on the semantics or grammatical components of English to teach how language is used. Yet, school subjects such as science are focused on the meaning of language. They require students to comprehend the vocabulary and language needed to understand concepts and explain those concepts orally or in writing.

In order to be successful in science, ELLs and striving learners need to learn language, learn about language, and apply specific language (to explain concepts and processes to interpret or critique theories) and meet the school's expectations. Learning language means developing depth and breadth of word meanings every single day in order to build background and keep up with new knowledge.

Even students who appear fluent in English, but struggle with academic English or learning subjects, need depth and breadth of word knowledge. Unfortunately, these students often get labeled as long-term ELLs, remedial students, or unmotivated students. Therefore, focusing on contextualized explicit instruction on the language of science is beneficial to all students. So, how do we go about teaching the vocabulary and skills to understand scientific concepts?

Vocabulary and Concept Development in *Content Essentials for Science*

Content Essentials for Science ©2009 is designed to help ELLs and striving learners learn language, learn about language, and learn content through language. The approach in *Content Essentials for Science* targets students who need background knowledge, concept building, and vocabulary development to comprehend and explain concepts of life science, Earth science, and physical science as well as the inquiry-based learning that is part of studying science. The main goal of *Content Essentials for Science* is to help all students build the vocabulary they need to read the texts mainstream students are asked to read and write about in school. There is a strong emphasis on academic vocabulary that is taught through context by:

- Preteaching key concepts and vocabulary; building background knowledge and language prior to whole-class lesson/textbook usage
- Reteaching key concepts and vocabulary after the whole-class lesson or textbook usage
- Explicit instruction in nonfiction reading strategies, including comprehension, text features and structures, and genres (e.g., how to read science books)
- Explicit instruction in understanding language, including word study (e.g., prefixes and suffixes) and language use (e.g., multiple-meaning words, homophones)
- Explicit instruction in content-driven writing (forms, research, reports)
- Independent student reference

Content Essentials for Science is built upon the premise that developing a repertoire of academic vocabulary also requires multiple exposures to words. Stahl recommended at least twelve exposures before a student mastered each word (Stahl 2005). Calderón (2007b) has found that mastery of any word for ELLs means knowing:

- How to decode it
- How to pronounce it correctly
- The meaning for comprehending the immediate text context
- Other important meanings (polysemy)
- How to spell the word
- How to use it correctly while writing summaries

The lessons in *Content Essentials for Science* ensure multiple contexts for academic vocabulary and focus on mastery of vocabulary through the above methods. Lessons feature conceptual illustrations that present content, concepts, and vocabulary in context. The illustrations scaffold understanding. The student handbook is divided into two parts to scaffold learning for science content and expository reading and writing skills. The interplay between content and literacy skills specifically facilitates learning for ELLs and striving students who need both the vocabulary to comprehend science content and the literacy skills to engage in the reading and writing required at their particular grade level. *Content Essentials for Science* provides materials for grades K–2, 3–4, and 5–6, focusing on the science standards and content for those levels.

Part 1: Science Essentials. The first part of the student handbook focuses on topics essential for understanding elementary science. This part includes full-page illustrative diagrams/graphic organizers and photos to support the text. By scaffolding content through text and visual support, *Content Essentials for Science* meets grade-level expectations for science content learning. In this way, science content is made accessible to ELLs and striving students but is not watered down. When teachers use visual aids such as the diagrams, photos, illustrations, and graphic organizers in the lessons, they build background on the concepts, which accelerates the learning for all students but especially for English Language Learners, who are trying to make sense of the language (Calderón 2007b). The highly visual format of the lessons provides striving students with another context (in addition to the text itself) in which to build and refine meanings. With this scaffold, students are able to access the science content and make sense of the science concepts at their grade level.

Part 2: Literacy Essentials. The second part of the student handbook focuses on reading and writing skills and uses real models to display the various text features, strategies, and genres used in science books. Sample topics include visual aids, such as graphs and tables; comprehension strategies, such as making connections, summarizing, and drawing conclusions; science writing topics, such as taking notes and writing summaries; and language knowledge, such as homographs, idioms, and common spelling problems in English.

Comprehension Strategies. Teachers can use the comprehension skills and strategies in Part 2: Literacy Essentials to help students develop an understanding of the science topics featured in Part 1: Science Essentials. Reading expository texts is quite different from the narrative reading that students do in reading classes. Students can benefit from ways to make the science content meaningful. The comprehension strategies in

Part 2: Literacy Essentials accomplish this by showing how a specific strategy such as making connections can be applied to science content. What makes the comprehension strategies even more meaningful for students is that the examples or models that are used in Part 2 are based on the science topics from Part 1 so students have background knowledge—a key part of scaffolding learning.

Writing Strategies. Just as the explicit teaching of comprehension strategies provides students with the academic skills needed to engage in grade-level expectations for expository reading and acquiring content knowledge, so too does the explicit teaching of writing strategies help students acquire grade-level content knowledge and literacy skills. The integration of writing skills and science topics facilitates literacy learning as well as content knowledge (Calderón 2007b). For example, when students write about what they read, they put ideas in their own words and in effect, make the content understandable to them. By explicitly teaching writing skills, teachers give students another tool for learning academic content and help to scaffold that learning through writing.

Technology and Ancillaries. The program also includes a technology component and other ancillaries to meet the needs of ELLs and striving students. A highly interactive and engaging technology component allows students to access the content at their language-ability level. It utilizes a wide range of multimedia elements to help build background knowledge, vocabulary, and connections to existing knowledge. The technology also provides support and individualized practice with words in all four critical language skills—listening, speaking, reading, and writing. In addition to the technology, the program includes activities, which provide practice and application with the academic vocabulary from the lessons, and transparencies, for instruction on the concepts. Explicit instruction and opportunities for developing and applying new vocabulary will help ELLs and striving readers be successful with the content they read in *Content Essentials for Science* and other texts as well as with their oral and written communication.

Selecting Vocabulary to Teach

Scaffolding ELLs and other struggling readers toward grade-level reading skills requires teachers to focus heavily on vocabulary development. Learning everyday Tier 1 vocabulary words (as described by Margarita Calderón) enables students to read with fluency the words that appear most frequently in written texts. Learning more complex Tier 2 vocabulary helps students negotiate more challenging texts that include

multiple-meaning words and abstract concepts prevalent in literary and content-related texts. And explicitly learning discipline-specific Tier 3 vocabulary words ensures that students build a foundation for content-area studies (Calderón 2007b).

Cognates. Tier 1, Tier 2, or Tier 3 words may be cognates. Cognates are words in two or more languages that almost sound the same or are spelled the same. For instance, in English and Spanish, words such as the following are cognates: *telephone/el teléfono, radio/el radio*, and *education/la educación*. Literate Spanish speakers have a great advantage over monolingual English speakers with Tier 3 cognates because many of them are high-frequency words in Spanish but low-frequency words in English (e.g., *coincidence/coincidencia, absurd/absurdo, concentrate/concéntrate,* and *fortunate/afortunado*. However, some students will need to learn the concept or specificity for some cognates (e.g., *adaptation/adaptación*).

False cognates, words that look like they would be cognates but aren't, also need to be pointed out by the teacher and the correct translation given: *rope/ropa, soap/sopa* (*ropa* means clothes and *sopa* means soup). Another example is the word *assist*, which is sometimes translated as *asistir*, but the correct translation is *atender*, and *attend* means *asistir*. Yet, *asistencia* means *assistance*, but *attendance* is not *atendencia* (this word does not exist), and it is also correct to say *asistencia*. Confusing enough? We call these *polysemous cognates*. They can be either true or false cognates, depending on the context.

The selection of words to preteach in *Content Essentials for Science* was based on research by Beck and colleagues (2002), the Bilingual Cooperative Integrated Reading and Composition (BCIRC) study (Calderón, Hertz-Lazarowitz, and Slavin 1998), and the Expediting Reading Comprehension for English Language Learners (ExC-ELL) study (Calderón 2007a). The framework for selecting words for ELLs is summarized as follows:

Tier 1 Words for English Language Learners. We take it for granted that native English speakers know most Tier 1 words, but this is not the case for ELLs. Many Tier 1 words may be unknown to ELLs and are key to the comprehension of a written passage. For Tier 1 words, ELLs typically know the concept in their primary language but not the label in English. For example, a Tier 1 word might be *sight*. This is a word that ELLs may not know, but it can be easily taught during a text presentation and discussion by role-playing. Another Tier 1 word might be *bug*. Words like *bug* (insect) may be easily taught during text discussion by pointing to a picture of a bug. However,

because many words are polysemous (have multiple meanings), they merit further instruction, which can be accomplished in oral language activities that follow the text discussion.

TIER 1

Words that ELLs need for everyday speech, for academic conversations and explanations, and for scaffolding more complicated text.

- Basic words that students know the concept and label in the primary language but need the English label (e.g., *bug, limb, role*, and *roots*).
- Simple idioms are basic expressions that ELLs are unlikely to know (e.g., *make up your mind* and *let's roll*).
- Connectors (e.g., *so, if, then, however, finally*).

Some Tier 1 words are cognates with a language like Spanish *(family/familia; radio/radio)*. The cognates in this category consist of words that are high-frequency words in Spanish and English; they do not require substantial instruction because students know the word meanings in Spanish.

Tier 2 Words for English Language Learners. These words are very important and useful because they are in grade-level texts and facilitate the understanding of Tier 3 words. Some Tier 2 words are those tiny words that make comprehension difficult for ELLs, such as *so, at, into, within, by, if,* and *then*. Others are sometimes clustered to connote certain usage, constructs, or "ways of talking about school stuff" as one teacher calls them. They are also called transition words. These are helpful to compare and contrast, to describe, or to give examples. The box on the next page has some examples.

In addition, many Tier 2 words are cognates (in this tier they are high-frequency words in Spanish and low-frequency words in English), and students whose first language shares cognates with English will have a head start with these words. Words in Spanish parallel words in English, such as *compare/comparar* and *information/información*. Many Spanish speakers will know both the concept and an approximation of the label in English. If they don't know the meaning in either language, both can be taught together. This category also includes less common idioms, idiomatic language, and metaphors that are key to making inferences.

TIER 2

Some criteria for identifying Tier 2 words:

- Importance and utility: Words characteristic of mature language users appear frequently across a variety of domains (e.g., *power, cell, right, leg, round*).
- Conceptual understanding: Words for which students understand the general concept but provide precision and specificity in describing the concept.

  Cause and effect – *because, due to, as a result, since, for this reason, therefore, in order to, so that, thus…*

  Contrast – *or, but, although, however, in contrast, nevertheless, on the other hand, while…*

  Addition or comparison – *and, also, as well as, in addition, likewise, moreover, by the way…*

  Giving examples – *for example, for instance, in particular, such as…*
- Polysemous words: These are some of the most troublesome words for ELLs. It is important to teach words like *plant* or *trunk* because ELLs typically only know one meaning, and that meaning may not be relevant to the context in which it is found. It is also necessary for ELLs to learn simple words, such as *set, table,* and *power* and how they are used in science as well as everyday life.
- Less common idioms and idiomatic language that ELLs do not know, such as "whole way through."

Tier 3 Words for English Language Learners. These words are limited to specific domains such as science and are important for understanding concepts. Many Tier 3 words are cognates because they are specific to certain content areas (e.g., *osmosis, photosynthesis, minerals*). However, students may not know the actual concept or process; therefore, they need to be pretaught along with the concept. This category also includes words that may not be essential to understanding the main points of the text. These can be explained briefly to the students but students don't have to master these words.

TIER 3

Low-frequency words in English.

These are the words that are limited to specific domains, such as social studies, math, language arts, or science. Although they are low-frequency words, they are very important for understanding content; for instance: *lathe, isotope, peninsula, osmosis, polysemy, hyperbole*—these words are all cognates.

Of course, cognates and polysemous words can be either Tier 1, 2, or 3. It depends on the difficulty of the word or the background knowledge of the student. By the same token, selecting words for the three tiers will also depend on the subject, grade level, and student background knowledge. Each classroom will be different. Each group of students will be different. Each will require an analysis of the words to be taught before, during, and after reading.

In *Content Essentials for Science*, vocabulary instruction is provided for Academic Content Words, On-the-Spot Words, and Academic Process Words. Descriptions of the words follow below. It's important to note that while many of the Academic Content Words are cognates with words in Spanish and other languages, so too can On-the-Spot Words and Academic Process Words be cognates. Polysemous words, or words with multiple meanings, may also be identified in any of the categories but most often are Academic Process Words.

- Academic Content Words: These words are integral to understanding the lesson concept. These words are identified for each lesson so that what is considered an Academic Content Word, or essential to understanding in one lesson, may differ in another lesson. In Part 1: Science Essentials, words are based on science standards. In Part 2: Literacy Essentials, they are based on literacy standards. Academic Content Words may be Tier 2 or Tier 3 words; they are key to the lesson. These words are highlighted in yellow in the student handbooks and called out in the Teacher Guide.
- On-the-Spot Words: These words appear as labels on pictures, diagrams, and visual aids in the student handbooks. Therefore, ELLs have the vocabulary needed to discuss photographs and other illustrative items and extend learning. In the Teacher Guide, labels that appear in the student lessons and other words from the text that can be easily taught at point of use in the lesson discussion are identified as On-the-Spot Words; they may be either Tier 1, Tier 2, or Tier 3 words.

- Academic Process Words: These words appear in the text in the student handbooks, but are identified only in the Teacher Guide. Academic Process Words may be Tier 1, Tier 2, or Tier 3 words. They provide students with the academic language needed to discuss concepts and make sense of content. They are often connectors or transition words that facilitate understanding, such as *so, if, then, within*. They have been selected from each lesson in the student handbook so the teacher can meet the specific needs of ELLs in teaching these words.

It is important to preselect words to teach before, during, and after reading to focus on the most important concepts from the standards and basic knowledge that will make a difference in students' test results. As students delve into the text, there will be other words you might not have even thought about. These can be collected and pretaught the following day, or they can be taught quickly so as not to interrupt the reading. The following section describes ways teachers and students like to conduct word-study activities in the context of learning content and preparing for exams. These strategies are incorporated into the *Content Essentials for Science* Teacher Guide. They occur as part of the lesson for teachers to introduce concepts and vocabulary, monitor progress and address the different levels of language learners during reading, and extend concepts after reading through modeling, applying comprehension strategies, and word study.

Teaching Vocabulary

Vocabulary development strategies are of importance for all students, but especially for ELLs (Fitzgerald 1995; García 2000; Blachowicz and Fisher 2004). Particularly effective vocabulary strategies include those described by Beck et al. (2002), Chamot and O'Malley (1996), Calderón et al. (2005), Calderón and Minaya-Rowe (2003), and Padrón (1992). August et al. (2002) propose the use of cognates (taught with derivational and inflectional morphemes and other strategies) as effective vocabulary tools for Spanish-speaking ELLs. This is particularly important in schools where 95 to 98 percent of the students are Latino. The Teacher Guide in the program identifies English and Spanish cognates from the student lessons so students can transfer their learning to new English words.

In addition to teaching cognates, three basic premises guide instruction of vocabulary:

Premise 1—100 Percent Student Interaction. A feature that is perhaps the most critical for ELLs and striving students success is the continuous and constant production on oral and literacy tasks. For every instructional and learning event,

students must produce and practice until there is evidence of mastery. For example, a teacher uses specific techniques such as, "Turn to your partner," choral responses, and others to ensure all ELLs and striving students are talking and practicing the new words. Instead of round-robin reading, teachers use partner reading to ensure 100 percent time on reading for all students. Instead of calling on one student for an answer, teachers use a strategy where all students discuss the answer and one student is called to represent the group. This method ensures all students prepare each other to respond successfully. The *Content Essentials for Science* Teacher Guide includes many of these activities and strategies for meeting the needs of different language levels of ELLs to ensure all students are engaged.

Teachers of English to Speakers of Other Languages (TESOL) identifies the following language levels: Starting, Emerging, Developing, Expanding, and Bridging. In keeping with these levels as well as the five levels identified by the World-Class Instructional Design and Assessment Consortium (WIDA) and the five levels identified in the *English Language Development Standards for California Public Schools*, *Content Essentials for Science* provides instruction in the Teacher Guide for meeting language levels as outlined below:

- Starting/Emerging—Instruction at this level focuses on conveying meaning through diagrams and illustrations with a focus on vocabulary. Instruction is provided for teachers to model language so students can then produce, repeat, and practice oral language skills, including short phrases or sentences. Students are provided with opportunities to further language practice and explore lesson content in a safe, low-anxiety environment, working in small groups or with partners. Students demonstrate, draw, or use short phrases or sentences to tell what they know.

- Developing—Instruction at this level focuses on providing students with practice talking to a partner to build fluency and scaffold learning. Instruction is provided for teachers to call on volunteers to explain lesson concepts, using sentences. Independent work is encouraged. Students demonstrate what they know through written work, i.e., write sentences and simple paragraphs.

- Expanding/Bridging—Instruction at this level focuses on providing students with opportunities to apply language, for example, by discussing lesson concepts in small groups or with a partner. Students engage with the text by reading or rereading key parts of the lesson and writing and sharing their work orally, using varied sentences and extended discourse.

All instructional levels ensure engagement of both English Language Learners and striving learners through providing instruction on vocabulary and concepts that does the following:

- Uses gestures
- Uses student-friendly definitions
- Uses multiple examples
- Elaborates or adds explanatory details to lesson concepts
- Solicits student examples
- Repeats key information and vocabulary
- Compares and contrasts ideas or topics
- Connects to students' experiences
- Has students build a mental model
- Has students make inferences
- Has students read aloud to build fluency

Premise 2— Semantic Awareness. A school, classroom, and learning environment must be permeated with a mindset that all students are constantly surrounded with language and vocabulary interactions. For example, a principal ends her announcements with "the word of the day." She states the word twice, gives a definition, and uses it in a sentence. As she walks around school the rest of the day, the students stop her and give their own sentence with the word of the day. Another example is when teachers meet in interdisciplinary teams and identify sets of high-utility words that cut across all content areas and polysemous words, such as *table, cell, power, radical*, and so on. They plan which words to teach on a weekly basis in order to ensure more than 12 exposures/encounters with a word in a variety of contexts. Strategies for recognizing and understanding these words are included in the Part 2: Literacy Essentials lessons. Each lesson in the Teacher Guide also provides instruction for developing oral language and word-study skills based on the different tiers of vocabulary.

Premise 3— The Explicit Teaching of Reading Comprehension. Explicit instruction for developing reading comprehension skills and strategies can be applied to other reading situations (Slavin and Madden 2001), such as content reading. The National Reading Panel (2000) found that comprehension-strategy instruction was important for students' reading growth. The features of explicit teaching include:

- Relevance: Students are made aware of the purpose of the skill or strategy—the why, when, how, and where of the strategy.
- Definition: Students are informed as to how to apply the skills by making public the skill or strategy, modeling its use, discussing its range of utility, and illustrating what it is not.
- Guided practice: Students are given feedback on their own use of the strategy or skill.
- Self-regulation: Students are given opportunities to try out the strategy for themselves and develop ways to monitor their own use of the strategy or skill.
- Gradual release of responsibility: The teacher initially models and directs the students' learning; as the lesson progresses, the teacher gradually gives more responsibility to the student.
- Application: Students are given the opportunity to try their skills and strategies in independent learning situations, including nonschool tasks.

The *Content Essentials for Science* program provides explicit strategy instruction as practical, replicable techniques. This instruction is effective as a routine part of English language development and reading within science. In addition to the instruction provided in the Teacher Guide, the student handbook also meets the need of developing vocabulary along with expository reading and writing skills. Part 1: Science Essentials focuses on the academic vocabulary needed to make content comprehensible to ELLs and striving students. Part 2: Literacy Essentials provides explicit strategy instruction for reading science, comprehension, understanding language, and writing for science. The following discussion takes a closer look at the research findings for when to teach words and what the strategies and skills instruction for teaching vocabulary to ELLs and striving students look like.

Preteaching Vocabulary

Preteaching vocabulary is critical to comprehension. Before students read a text, or a teacher reads a text aloud to the students, or a teacher lectures, it is vital to preteach six or seven words that are key to comprehending that text or lecture. There may be many words ELLs and striving students do not know in each subject area. Therefore, the selection of those six to seven words to preteach in all content classrooms needs special attention. Teachers can select two or three words from each tier each day, as students progress through a textbook or a combination of reading, discussions, lectures, and summarizing of content.

Seven-Step Process. Preteaching vocabulary is a seven-step process that integrates second-language strategies, academic language sentence structures, and redundancy in hearing and using the word. The following seven-step process is part of the instruction for each lesson in the *Content Essentials for Science* Teacher Guide:

(1) The teacher says the word.

(2) The teacher states the word as it is found in the context of the text.

(3) The teacher provides a definition or key definitions from the dictionary (the students do not provide these because they might select the wrong definitions).

(4) The teacher provides another example of the word in a way that clarifies the word's meaning in student friendly terms.

(5) The teacher asks students to repeat the word at least three times to build a phonological representation of the word and model pronunciation.

(6) The teacher ensures 100 percent of the students become engaged with the word through oral language activities. The production activity can be carried out with a partner. For instance, the teacher might say, "Tell your partner about a time you made a correct *inference*." After a minute of sharing with partners, the teacher asks two or three students to share what their partner said. "Turn to your partner" and "Tell me what your partner said," ensures 100 percent production by all students because all are using the word at the same time and hearing it several times from others. When students have to report to the teacher what their partner said, they need to apply it again from a different reference point, a different context, using it with related words and phrases. This discourse sequence helps ELLs anchor their knowledge of the word. It helps non-ELLs achieve higher levels of specificity. It also develops listening and paraphrasing skills, third-person pronoun-verb agreement (e.g., "My partner says…"), and other grammatical structures.

(7) The teacher points out special characteristics about that word (e.g., cognate, polysemous, tense, spelling, prefixes).

Here is an example of how teaching the word revolution might look through the seven steps:

(1) *Revolution*. Say *revolution* three times with me.

(2) The text says: _____.

(3) The dictionary defines it as, "the overthrow of a government or social system with another taking its place." Another meaning I see here is "movement of a body, a star, or planet in a circle." The revolution of the Earth around the Sun takes how long?

(4) Earth takes one year to orbit, or circle, the Sun. This movement is called one revolution.

(5) Say *revolution* with me three times.

(6) With these objects, show the revolution of the Earth. Work with your partner. [after 1 minute] What did your partner say?

(7) Let's say (or spell) the word. Does anyone know the cognate in Spanish? (If applicable).

100 Percent Engagement. There are many other ways of getting students engaged with a word. It does not always have to be a partner activity. Students can respond chorally or in popcorn style (students call out answers as they think of them), or by applause or thumbs-up signals. The following are examples of strategies that may be used in the *Content Essentials for Science* Teacher Guide:

> Answer teacher questions by giving reasons or examples:

If you are walking into a dark room, you need to do it cautiously. Why?

> Use critical-thinking skills while learning words, selecting or making choices.

Which of these things would be an organ? Answer in a complete sentence.

- skeleton
- stomach
- hand

> Think about specificity when using adjectives, verbs, or nouns.

Applaud if you hear an adjective:

- affected
- few
- mainly
- farther

When teachers use strategies such as these to preteach vocabulary, they are also teaching or reviewing other skills, concepts, and/or metacognitive strategies. With the

example of the *organ* question students need to listen carefully, compare the choices, and choose the most appropriate one. They have to think quickly, make inferences, and respond. The teacher can ask for complete sentence responses, so students can practice answering long strands of discourse, scaffolded by the teacher's phrases. This ensures appropriate answers, the use of "would be" and other more sophisticated patterns (e.g., The stomach would be an example of an organ). Responding in complete sentences creates a sense of confidence and self-efficacy in ELLs and other students as their responses become more and more sophisticated. The language-level differentiation that is provided in the *Content Essentials for Science* Teacher Guide for each lesson is based on this research to ensure appropriate scaffolding for all students, including specific direction for those working at Starting/Emerging, Developing, and Expanding/Bridging language levels.

Developing Vocabulary during Reading through Discourse around Text

Vocabulary is also developed through ongoing dialogue between the teacher and students about the text during teacher and student reading. Reading begins with the teacher reading aloud the first two paragraphs or so of a text. During the read aloud, the teacher uses different types of questions, stopping at specific intervals in the text to elicit discussion and teach more words "on the run." Different methods are used depending on the nature of the word (is it concrete or can it be demonstrated), its cognate status, depth of word meaning, and utility. Strategies for teaching English Language Learners such as the following can be used to teach words on the run. The use of pantomime and gestures, showing pictures and real objects, and doing quick draws on the board can be used to quickly explain what a word means.

Questions can also help prompt students to talk about ideas using the target words. Questions have to be carefully crafted ahead of time. Some questions elicit one-word responses or are likely to elicit only sparse responses. Other questions can help students move from using just pictures and background knowledge to more elaborated responses tied to the text. The Teacher Guide provides differentiated instruction for use during the reading of each lesson and identifies On-the-Spot words that can be taught during reading.

Teaching Vocabulary after Reading

The language development activities that follow reading are based in large part on the words the story or text has provided. Different lessons lend themselves to different

kinds of oral activities that help further language ease. Nevertheless, the key focus is on developing conceptual knowledge about the words and reinforcing labels for the words. The following examples focus on different syntactic and semantic features of English. Many of these are explicitly taught in the program, in Part 2: Literacy Essentials and again in the Teacher Guide as part of extending concepts for each lesson.

Homophones

Graphic organizers are great tools for ELLs and striving students to organize information. For example, students can provide short definitions for homophones such as *right* and *write* in a chart like the one below. Teachers can extend learning by asking students to use the new words in discourse through oral summaries or retelling.

HOMOPHONES TO KNOW

Word	Meaning
eye	body part used for seeing
I	myself
hole	empty place
whole	everything, all
knew	was sure of
new	not *old*
mail	letters sent by the post office
male	opposite of *female*
pair	a set of two
pear	a kind of fruit
right	correct, not *left*
write	use a pen or pencil to make words
weather	conditions outside
whether	if
wood	material from trees
would	ought to or should

Polysemous, Homographs, or Multiple-Meaning Words

Polysemous words, like those on the next page, are also called homographs or multiple-meaning words; they are words that are spelled the same but have different meanings. It is up to the reader to apply the correct meaning based on the context. In order for

students to understand and remember the multiple meanings of words, they need to see how the words are used across content areas.

HOMOGRAPHS/POLYSEMOUS WORDS

Word	Meanings
bark	· the sound a dog makes · tough covering of a tree
kind	· gentle, friendly, nice · type or variety
left	· opposite of right · went away · remainder
palm	· kind of tree · flat inside of your hand
rest	· sleep · relax or take a break · what is left
top	· highest part · a cover or lid · a spinning toy
yard	· unit of measure · area near a house
bear	· a large furry animal · to carry or support
desert	· dry climate · leave behind
down	· soft feathers · opposite of *up*
produce	· make appear · fresh fruits and vegetables
root	· plant part that grows underground · cheer for
well	· healthy, not sick · hole dug for water

An activity that helps students learn polysemous words that cut across several content areas is to provide a list of these words and have students discuss and write sentences with each. For example:

Write as many sentences as you can using each word for math, science, social studies, and/or language arts:

- prime
- power
- radical
- imaginary
- right
- set
- leg
- cell
- round

Teachers have used the following activities after reading or for review of polysemous words:

> Locate polysemous words in the text.
> Use the dictionary to find the multiple meanings of a word.
> Challenge other teams with multiple meanings of words.
> Invent a rap, chant, song, or a silly sentence using the multiple meanings, for example, "The trunk with the elephant's trunk was found under the tree trunk and put in the car trunk along with our swimming trunks."

Prefixes and Suffixes

Explicitly teaching prefixes and suffixes to students provides them with the knowledge to comprehend new vocabulary. Prefixes and suffixes are used across all content areas and can be an effective part of strategy instruction in science.

The next pages provide examples of prefixes and suffixes that may be used in science.

Prefixes

PREFIXES		
Prefix	**Meaning**	**Example**
over-	too much	overheat, overgrown
mis-	wrong, not	misuse, mistaken
pre-	before	prefix, preview
de-	down, away	decrease, depart
un-	not	unhealthy, unusual
re-	again	react, recycle
im-	not	immature, impossible
in-	not	invisible
ir-	not	irregular
il-	not	illegal, illegible
dis-	not, opposite	disappear, disagree
en-	in	endanger
em-	in	embedded
non-	not	nonfiction, nonliving
im-	into	implant
in-	into	inject, inhale
sub-	under, below	subzero, submarine
inter-	with, between	interact, interfere
fore-	the front part	forehead, forearm
trans-	through	transparent, transform

Suffixes

SUFFIXES		
Suffix	**Meaning**	**Example**
-ly	in a certain way	calmly, tightly
-er	one who, more	teacher, warmer
-ist	one who does or makes	scientist
-or	one who	inventor, actor
-ion	state or quality of	champion
-tion	state or quality of	evaporation
-able	is, can be	breakable, suitable
-ible	is, can be	edible
-al	relating to	natural, survival
-ial	relating to	partial
-y	state or quality of	hazy
-ness	state or quality of	goodness
-ity	state or quality of	possibility
-ty	state or quality of	honesty
-ment	action or process	amazement
-ic	relating to	scientific
-ous	full of	joyous
-eous	full of	gaseous

There are many ways to teach word knowledge such as those just discussed. The following are examples of team or individual written exercises that help students reinforce word meanings, apply multiple meanings of words, as well as analyze and play with prefixes, suffixes, and parts of speech in sentences. The following exercises can also be given as homework or as activities for when students have finished their work. Some teachers have these exercises handy for times when they still have five minutes before the bell rings!

Text Tools

Students like to use sticky tabs, sticky notes, colored markers, colored dots, or colored pens to categorize words or keep track of words they have mastered. Students underline, highlight, box, circle, and write over new words. They underline with red the words that are the hardest; in yellow those they think they know; and, use green for those they definitely know.

Word Puzzles

Students can work on their own or with peers on the following activities to focus on the smaller units of word analysis. The teacher can post these activities for students to complete if they finish class assignments before others.

- Find compound words, prefixes, and suffixes in the text.
- Break up compound words and put together other words with each part.
- Use affixes such as *gram, photo, graph, geo, phon, cycl, deci, scribe, vid, dyna* and tell which subject they would be most likely to find that word.
- List as many key words as they can remember from a chapter.
- Challenge other teams to find several key words in a text, while timing them.

Cooperative Learning

When a classroom is composed of a variety of language and literacy levels, teaching strategies such as the ones described next help address differentiation. Students get to practice more language with hands-on cooperative activities and are cognitively challenged at all times. In cooperative teams, ELLs and striving students can learn from what is being displayed. They learn through experiments as they proceed with their hands-on learning tasks. ELLs need multiple opportunities to use language through problem-solving, self-generated elaborations, making affective connections, incorporating graphic and visual representations, pursuing a personal interest through generating and answering questions, and exercising a sense of personal control through interaction with peers.

Working in pairs or teams of four makes learning fun and easy. Teachers like cooperative learning because they can monitor student learning much easier. They can also conduct instructional conversations where students are guided to use the words they are learning, to discuss the topics they are studying, and to ask the teacher questions. The following are some techniques that can be used to generate individual accountability and rich discussions around science.

Reviewing Words with Peers

- Draw a cartoon using the word.
- Design a creative way of representing the word.
- Invent a mnemonic device to remember the word, such as a brief chant, rhyme, rap, joke, or even a Shakespearean iambic pentameter stanza.
- Try to come up with as many synonyms for the word as possible.
- Try to come up with as many antonyms for the word as possible.
- Use all the words of the week to develop word games to play with other pairs of students.
- Put words on cards with clues and challenge another pair of students.
- Act the word out or invent a motion to match the meaning; play charades with another student pair.

Reviewing Words with Numbered Heads Together

1. Students number off from 1 to 4.
2. The teacher gives students a typed list of Tier 1, 2, and 3 words learned that week.
3. Students must make sure everyone on the team knows the definition, spelling, pronunciation, and how to use the words in a sentence.
4. The teacher calls a number. The corresponding student is given a word and must answer for the team by saying it, spelling it, and using it in a sentence.

Reviewing Words with Expert Jigsaw

1. Teacher gives each team a different set of laminated index cards with vocabulary words on one side and definitions on the other.
2. Students must make sure everyone in the team knows the definition, spelling, pronunciation, and how to use it in a sentence.
3. Then, every three minutes two students go to a different table to teach and test those students.

Reviewing Words before a Test

1. Students form a "Conga Line" or "Tea Party Line" or "Texas Two-Step Line."
2. They bring lists of words and stand in front of a partner.
3. With partner number one, they practice using words in sentences or reviewing definitions before their test.

4. When the music starts, they move to the next partner to practice more words.
5. They continue changing partners and studying words for about five minutes or until the test is given.

Reviewing Words with Vocabulary Roundtable

Teams use only one paper and one pencil. In round-robin style, each student on the team writes one word (and/or sentence) learned that week and passes the paper to the right. The next student writes a different one, and so on, until the teacher calls time. The team with the most words wins.

Conclusion

With explicit strategies and instruction, teachers can teach vocabulary effectively to ELLs and striving readers. However, the linguistic and cognitive challenges of academic language for ELLs can be overwhelming when language, reading, and content are taught separately. This paper explains and provides the research foundation for how language, literacy, and knowledge accelerate when these are integrated and a large chunk of instructional time is given to vocabulary development (Calderón 2007a and 2007b). *Content Essentials for Science* builds on this and other research and employs a comprehensive system for addressing each challenge.

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