

Using the SIOP Model to Improve Middle School Science Instruction

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Introduction

The achievement gap between English language learners and their English-proficient peers in U.S. schools is persistent and well documented (California Department of Education, 2004; Lee, Grigg, & Donahue, 2007; Siegel, 2002). Research shows that among in-school factors that contribute to student achievement, teachers have the biggest impact. Given this, it is imperative that all teachers know how to make academic content comprehensible to learners who are not yet proficient in English.

One promising approach to improve the academic performance of English language learners is the SIOP (Sheltered Instruction Observation Protocol) Model, an empirically tested, research-based model of sheltered instruction developed by researchers at California State University, Long Beach, and the Center for Applied Linguistics under the auspices of the National Center for Research on Education, Diversity & Excellence (Echevarria, Vogt, & Short, 2008). The SIOP Model is a lesson planning and delivery system that incorporates best practices for teaching academic English and provides teachers with a coherent approach for improving the achievement of their students. Using strategies and techniques that make academic content comprehensible to students, teachers present curricular content concepts that are aligned with state standards. While doing so, teachers are developing students' academic English skills across the four domains—reading, writing, listening, and speaking—in addition to building their academic vocabulary.

Many features of the SIOP Model, such as cooperative learning, reading comprehension strategies, and differentiated instruction, are recommended for high-quality instruction for all grade levels and content areas (Echevarria, Vogt, & Short, 2008; Genesee, Lindholm-Leary, Saunders, & Christian, 2006). However, the SIOP Model adds key features for the academic success of English language learners, such as including language objectives in every content lesson, providing opportunities for oral language

practice, developing background knowledge and content-related vocabulary, and emphasizing academic literacy. It is not a step-by-step approach but rather a framework for organizing best practices. The SIOP Model provides teachers with specific lesson features that, when implemented consistently and to a high degree, lead to improved academic outcomes for English language learners (Echevarria, Short, & Powers, 2006; Short, Fidelman, & Louguit, 2009).

SIOP Model

- Lesson Preparation
- Building Background
- Comprehensible Input
- Strategies
- Interaction
- Practice & Application
- Lesson Delivery
- Review & Assessment

Use of the SIOP Model in Science

Science is a subject with high language demands. As of 2007-2008, it is also one of the subjects in which student assessment is mandatory under the No Child Left Behind legislation. By using the SIOP Model to plan and deliver science lessons, teachers can better meet the unique linguistic and academic needs of their students learning English. Drawing from the middle school science curricular units that we created for the National Center for Research on the Educational Achievement and Teaching of English Language Learners (CREATE), we will highlight key features of the SIOP Model that illustrate ways in which teachers can support English language learners' academic English development and acquisition of science concepts.

Content and Language Objectives

A central feature of the SIOP Model is the inclusion of content and language objectives for every lesson. Content objectives identify what students will learn and be able

to do in the lesson, and language objectives address the aspects of academic language that will be developed or reinforced. These objectives should be stated in clear and simple language and posted for the students to see. They should be read aloud at the beginning of the lesson so that both teacher and students understand the lesson's purpose, and reviewed at the end of the lesson to determine whether the objectives were met.

Many teachers already use content objectives to ensure that standards-based curricular concepts are covered in their lessons, but they are less likely to include objectives that support the linguistic development of English language learners. Here are some steps teachers can take to create language objectives. (For further information, see Echevarria, Vogt, & Short, 2008, chapter 2.)

1. Decide what key vocabulary, concept words, and other academic words students will need to know in order to talk, read, and write about the topic of the lesson. Those words might be taught as a language objective. They should include technical terms, such as *ecosystem*, and terms like *distribution* that have different meanings across content areas. Other terms to highlight are those that English language learners may know in one context, such as *family* (as in parents, siblings, etc.), but that have a different use in science (e.g., family of elements in the periodic table).
2. Think about the language skills necessary for students to accomplish the lesson's activities. Will the students be reading a textbook passage to identify the stages of mitosis? Are they able to read a text passage to find specific information? Will students be reporting what they observe during a scientific demonstration to a peer? Do they know how to report observations orally? Acquiring the skills needed to carry out these tasks might be the focus of a language objective.
3. Identify grammar or language structures common to the content area. For example, many science textbooks use the passive voice to describe processes. Additionally, students may have to use comparative language to analyze two related concepts. Writing with the passive voice or comparative phrases might be a language objective.
4. Consider the tasks that the students will complete and the language that will be embedded in those assignments. If students are working on a scientific investigation together, will they need to explain the steps of the procedure to one another? The language objective might focus on how to explain procedures aloud.

Here are sample language and content objectives from our middle school science lesson on cell theory.

- Language Objective: Students will be able to orally describe three types of cells to a partner.
- Content Objective: Students will be able to produce a visual representation of each of the three types of cells.

It is important that the objectives be measurable. One way to ensure this is to choose appropriate, active verbs such as those in the chart below.

Content	Language
Apply	Compose
Categorize	Scan
Calculate	Discuss
Design	Read
Identify	List
Select	Persuade
Create	State
Hypothesize	Record
Use	Listen

Emphasis on Key Vocabulary

A consistent finding in reading research is the positive correlation between a learner's vocabulary knowledge and reading comprehension ability (Baumann, Kame'enui, & Ash, 2003). For example, students must be able to understand 90% of the words in a passage to comprehend the passage independently (Nagy & Scott, 2000). Given this, it is important that teachers include activities and opportunities for English language learners to develop their academic English vocabulary in specific content areas.

We suggest that teachers focus on approximately five vocabulary words per lesson. It is important to list vocabulary words for students to see and to include activities where the students can interact with the words in multiple ways. For example, students can create Four Corners vocabulary cards for all the new terms (see example below). In this activity, students divide a piece of paper into four quadrants, in which they do the following:

- Top left: Write the word.
- Top right: Write a definition in their own words.
- Bottom left: Draw a picture representing the word.
- Bottom right: Write a sentence using the word.

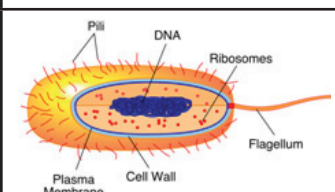
Prokaryote	An organism whose cell lacks a nucleus and some other cell structures
	Prokaryotes live in your intestine.

Image from www.physicalgeography.net/fundamentals/images/prokaryote.jpg. Reprinted with permission.

Below is a portion of a middle school science lesson on cells that aims to build the students' academic vocabulary.

- In groups of four, have students read several pages in the textbook on single-celled organisms, multi-cellular organisms, prokaryotes, and eukaryotes.
- Have students list similar and distinguishing characteristics of each type of cell in the appropriate columns on the graphic organizer (see example below).
- To help the students compare and contrast prokaryotes and eukaryotes, write one list of words on the board that signal comparing (*similarly, both, alike, shared*) and another list of those that signal contrasting (*however, on the other hand, different, but*).
- Model writing two sentences comparing and contrasting the characteristics of the organisms.
- Have students write two to four sentences of their own in their notebooks.

	Prokaryote	Eukaryote
Similarities	- enclosed by plasma membrane - contains ribosomes - has DNA	- enclosed by plasma membrane - contains ribosomes - has DNA
Differences	- has no nucleus - less developed than eukaryote - contains no organelles independent of the plasma membrane	- has a nucleus - ribosomes are bigger and more complex - contains many organelles with their own membranes

This part of the lesson offers the students numerous opportunities to learn and use new vocabulary. First the students read passages in the textbook that describe the four types of organisms (single-celled organisms, multi-cellular organisms, prokaryotes, eukaryotes) in detail and then use comparative language to compare and contrast their traits. Finally, students integrate their knowledge of the science vocabulary and comparative language forms to write sentences about the organisms. Note the emphasis on technical words (e.g., *prokaryotes*) and the language of general academic discourse (e.g., *shared, similarly*).

Frequent Opportunities for Interaction

In order to fully connect with the content concepts and develop a deeper understanding of the content-specific vocabulary, students must have many opportunities to use the language in authentic situations. Additionally, by providing students with multiple opportunities to interact with each other, the teacher creates an environment where every student in the class is developing oral literacy. The typical classroom discussion where the teacher asks a question and one student answers is not conducive to provid-

ing an environment rich in meaningful oral interaction. Teachers need to build activities into the lesson that require students to talk with their peers about the key concepts by using the key vocabulary terms. Fortunately, the hands-on nature of the science classroom fosters opportunities for peer-to-peer discussion of concepts.

The following middle school science activity, “Carousel,” about different types of cells, promotes purposeful interaction about the lesson content.

- Make two sets of three sheets of chart paper. Label each sheet in a set with the name of one of the three types of cells: prokaryote, eukaryote, and bacteria. Post one set along one side of the classroom, and post the other along the opposite side.
- Divide the class in half and have each half divide into three groups. Each group reviews its notes on the three types of cells.
- Assign each group to one of the chart posters on their side of the room.
- Give each group a different colored marker and tell them to write on the chart as many structures in that cell as they can in one minute. When time is up, instruct the groups to move clockwise to the next poster of their set.
- Groups move to another poster and repeat the procedure. If students encounter information from another group that they think is incorrect or have a question about, tell the students to write a question mark next to it.
- Once each group has visited all three posters in their set, go over the information as a class.

In this activity, students discuss the three types of cells with one another in small groups, record their ideas, and review ideas from other groups. Activities like this give English language learners an opportunity to develop oral language proficiency, which is positively correlated with reading and writing ability (August & Shanahan, 2006; Genesee et al., 2006). By structuring the lesson so there is more student interaction and engagement, teachers more effectively develop students' English language proficiency in all domains.

Review and Assessment

Although the emphasis in education is often on summative assessment (i.e., end-of-year or end-of-unit assessments that determine to what extent learners have mastered specific competencies), formative assessments (i.e., daily, ongoing monitoring through observations, questioning, and informal assessments) help teachers know when they need to modify instruction. Formative assessments may indicate lesson concepts that are not clearly understood

or identify specific topics that students do not understand, which allows teachers to adjust their instructional plan accordingly. The Word Splash (Ur & Wright, 1989) example below illustrates how students' knowledge of new vocabulary from a lesson about the three types of cells can be formatively assessed.

- Write on the board new vocabulary words (*prokaryote, eukaryote, organelles, unicellular, multi-cellular, bacteria, flagellum*).
- Have student groups look at the words. After a minute or less, quickly erase one of the words.
- Tell the groups to write down the erased word. Inform the students that every student in each group must know which word was erased because you will call on the group members at random. Once everyone in a group has the same answer, everyone should raise their hands.
- Ask a student from the first group with raised hands to say the word, spell the word, and use it in a sentence. Tell the student to ask for assistance from the group if needed.
- Continue until all the words have been erased.

At the conclusion of a SIOP lesson, the teacher reviews the new vocabulary introduced and practiced in the lesson with the students and revisits the content and language objectives stated at the beginning. For example, the teacher might say, "Let's see if we met our content and language objectives for today." Then the class can assess whether the objectives were met and how.

Conclusion

Processing academic language and understanding science concepts are cognitively demanding activities. English language learners need their attention drawn to key vocabulary and concepts in context so they can see the connections between the objectives of the lesson and the way the lesson was enacted. Emphasizing key vocabulary, creating opportunities for student-to-student interaction, and reminding students of the lesson objectives are some of the many ways that the SIOP Model can help students develop academic language proficiency and support learner autonomy in subjects with high language demands, such as science. To learn more about lesson preparation using the SIOP Model, see Echevarria, Vogt, & Short (2008).

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This brief was produced by CREATE with funding from the U.S. Department of Education (ED), Institute of Education Sciences, under Contract No. ED-R305A05056. The opinions expressed in this report do not necessarily reflect the positions or policies of ED. This document is in the public domain and may be reproduced without permission.