







State School Officer, 2010) and with English Language Development Standards.<sup>2</sup> An overview of each lesson lists the relevant objectives.

### **Methods to Develop Science Knowledge**

The intervention materials and instructional practices were built on a highly rated inquiry approach to teaching science to monolingual English speakers developed by the Biological Science Curriculum Study (BSCS) and used in the research cited above. The approach puts a premium on hands-on experimentation that aids students in building their own understanding of new concepts. The model uses a 7-E approach to learning: elicit, engage, explain, explore, elaborate, evaluate, and extend (Eisenkraft, 2003). Beginning with the “elicit” stage, teachers elicit information about students’ prior knowledge of the lesson’s content by presenting the content and language objectives, allowing students to evaluate their prior understanding of the lesson’s material. The goal of the “engage” stage is to get students interested in the upcoming task. Examples of activities during this stage include a quick demonstration, a short video clip, or a provocative question with discussion. The “explain” stage occurs at any appropriate time during a lesson, most often in conjunction with the “explore” phase.

During the explain stage, students work to more fully understand the new concepts, models, theories, and laws introduced in the lesson. Activities may include such activities as listening to teacher explanations, reading, watching videos, and discussing their observations, ideas, and hypotheses, and posing questions. In the “explore” stage, students get directly involved with the key concepts involved in the lesson through a variety of hands-on activities. During these investigations, students identify variables, necessary materials and research questions; conduct experiments; record data; plot graphs; interpret results; and communicate findings.

In the “elaborate” phase, following the hands-on investigations, students have an opportunity to apply the concepts they have learned to new contexts and to develop new questions and hypotheses to explore through further research. Examples of activities include further lab investigations, involvement in related projects, or solving similar, related problems. During this stage students are refining and deepening their understanding of the concepts by experiencing new applications and perhaps even exceptions.

The “evaluate” stage consists of formal and informal assessments that are ongoing. They may involve lab reports, oral presentations, or discussions where the teacher is looking for students’ ability to apply new concepts and skills. Finally, in the seventh stage, “extend,” students have an opportunity to more independently apply their understanding of scientific concepts and their academic language through reading, writing, and other activities on the lesson’s content.

### **Methods to Develop Academic Language**

Students’ academic language is developed in the context of science instruction through explicit instruction of individual words, sentence structures common in science, word-

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<sup>2</sup> Because the WIDA English language development standards are currently used in 29 states, we reference these standards.

learning strategies, and comprehension strategies, as well as through immersion in rich language and literacy environments.

### *Individual Words*

Students are taught approximately 10 new vocabulary words per week. These words are selected from the seventh grade curriculum and include words that are general academic vocabulary (e.g., *structure, development, function*) and science content vocabulary (e.g., *organism, cell*). The general academic vocabulary has been selected based on its frequency in academic texts (Academic Word List) and middle grades assessments that have been used at the state level. The science content vocabulary has been selected because it is essential to understanding key science concepts presented in the lessons.

Students also work with a glossary of the key vocabulary introduced in each lesson. The glossaries present pictures that demonstrate each key word along with the English and Spanish definitions of each word. There are spaces for students to rewrite the word; indicate if the word is a cognate with Spanish; create a sentence of their own by completing a sentence stem or jotting down notes; and draw a picture that illustrates the word's meaning.

### *Sentence Structures Frequently Used in Science*

Students are exposed to several sentence structures frequently used in science, including definitions, cause and effect, and compare and contrast.

### *Word-Learning Strategies*

Students are taught strategies to improve word learning (e.g., drawing on cognate knowledge; transforming verbs to nouns through nominalization; and using root words, base words, and affixes).

### *Comprehension Strategies*

Students are taught to visualize, select important information, summarize information, and generate questions. These methods have been validated as effective by the National Reading Panel (NICHD, 2000)

### *Immersion in Rich Language Environment*

The curriculum creates many opportunities for extended discussion among teachers and students as well as between students. For example, once during each lesson, students participate in shared interactive reading of a textbook<sup>3</sup> in which the meaning of science content vocabulary, general academic vocabulary, and science content is clarified. In the course of reading, the teacher will do the following:

- Begin with a guiding question related to the key information presented in the text.

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<sup>3</sup> Excerpts from the following textbooks were used for the shared interactive reading:

Durán, E., Gusman, J. & Shefelbine, J. (2005). *ACCESS Science: Building Literacy Through Learning*. Wilmington, MA: Houghton Mifflin Great Source.

Biggs, A., Daniel, L., Feathre, R.M., Lederman, N.G., Ortleb, E., Rillero, P., Snyder, S.L., & Zike, D. (2002). *Glencoe Science: Grade 7 Texas Science*. New York, NY: McGraw Hill.

- Review the meanings of key words and other words essential to understanding the text through brief explanations and reference to illustrations.
- Pose questions that alternate between questions for individuals and questions for partners. The questioning techniques employed are drawn from Bloom’s Taxonomy (1956), a widely used classification system that categorizes question types according to the level of abstract thinking required to answer the question. The levels of questions in order of difficulty, beginning with the easiest, are knowledge, comprehension, application, analysis, synthesis, and evaluation.
- Model comprehension strategies that are important tools for students in making meaning of text as independent readers. The strategies may include visualizing, drawing inferences, summarizing, and generating questions.

Teachers use an Echo-Elaborate-Elicit (“3 E”) technique designed to develop students’ language proficiency and content knowledge. It consists of the following:

- If the student’s response is correct, the teacher can repeat or echo what the student has said to note its importance and to ensure that the rest of the class has heard it.
- If needed, the teacher can elaborate on students’ responses by correcting pronunciation, grammar, and content knowledge, and adding additional information.
- The teacher can elicit a more comprehensive response from the student by prompting for further information/explanation.

## **English-as-a-Second-Language Techniques**

The research literature highlights the importance of building on effective first-language science research but also taking into account the language and cultural backgrounds of students (Lee, 2005) by scaffolding science instruction (e.g., through classroom discourse) so it is more comprehensible for English learners (Parkinson, Jackson, Kirkwood, & Padayachee, 2007).

CREATE Science is aligned with the 8 components and 30 features of the Sheltered Instruction Observation Protocol (SIOP) Model designed to help make content comprehensible for English learners. For example, with respect to lesson preparation, the CREATE Science lessons fully incorporate the following features: content and language objectives that are clearly defined, displayed, and reviewed with students; content concepts appropriate for students’ ages and educational backgrounds; supplementary materials used to support the core curriculum and contextualize learning; adaptation of content to all levels of student proficiency; and meaningful activities that integrate lesson concepts with language practice opportunities.

## **Flexible Student Grouping**

Students work individually, in pairs, and in small groups to carry out the science activities. For “Partner Work,” students are assigned a partner and work in pairs. “Partner Talk” allows students more time to talk, thus increasing student engagement. Limited-

English-proficient students are partnered with more proficient English speakers as a way to help build students' oral English proficiency. Students also work in small groups to carry out the science explorations.

## **Motivation**

Students' motivation and engagement are explicitly supported through (a) providing engaging hands-on activities; and (b) providing students with opportunities to work individually and collaboratively as English learners.

## **Reinforcement**

Research indicates that cumulative reviews are important for retention of content. Over the course of the lessons, key concepts are reinforced on a continual basis through initial review of previously taught materials and word-learning games.

Additionally, students are assessed for their science knowledge and knowledge of instructed vocabulary during the last lesson of each weekly sequence. It is crucial that teachers review the assessments with students so they can correct any incorrect responses.

## Appendix A

### Overview of the Model Lesson Sets

Each weekly schedule follows an established pattern.

#### LESSONS 1 AND 2 (Each 90 minutes)

Lessons 1 and 2 follow the “7 E” Model of science instruction:

Stage	Description and sample activities
<i>Elicit</i>	Teachers elicit students’ prior knowledge of the daily lesson topic and introduce the content and language objectives.
<i>Engage</i>	Students are hooked into the lesson topic through quick demonstrations, interesting readings, provocative discussion questions, and video clips or other graphic displays.
<i>Explain</i>	Students learn the models, laws, or theories behind the lesson topic and related vocabulary terms.
<i>Explore</i>	Students are involved in hands-on activities to directly work with key lesson concepts. Graphic organizers help students record information learned during the experiments, including graphing and summarizing results. Depending on the lesson topic, this stage sometimes occurs prior to the <i>explain</i> stage, in keeping with the inquiry model of science instruction.
<i>Elaborate</i>	Students formalize their understanding of the concepts and deepen this knowledge by applying the knowledge or skills to new concepts. Students participate in a shared interactive reading with the teacher modeling fluent reading of grade-level text, stopping for comprehension checks, and encouraging higher-order thinking through partner discussions.
<i>Evaluate</i>	This stage consists of ongoing informal and formal assessments of both language and content. Students complete cloze sentences, review key science concepts, and enter notes in their weekly vocabulary glossaries, which help to reinforce the vocabulary that they have learned through the hands-on activities and guided reading (each glossary entry includes a visual image, an English definition, a Spanish translation, cloze sentences to complete, and space for children to write notes or make a sketch).
<i>Extend</i>	Students refine their understanding through further readings, solving word problems related to the lesson topic, or completing crossword puzzles with lesson vocabulary.

#### LESSON 3 (50 minutes)

Lesson 3 is devoted to a review of the science content and vocabulary covered in the two weekly lessons (Lesson 1 and Lesson 2). Students begin with games that reinforce the vocabulary they learned, participate in assessments of science and vocabulary, and then review the assessment results with teachers, correcting their mistakes.



## **Appendix B**

### **Research Base**

A recent study (August, Branum-Martin, Cardénas-Hagan, & Francis, 2009) found that methods used in CREATE Science (called “Project Quest—Quality English and Science Teaching” in the study) were effective in developing the science knowledge and academic language of both English learners and English-proficient middle grade students. In the study, 10 sixth-grade science teachers in 5 middle schools in a large south Texas district participated in the study. For each teacher, two sections were randomly assigned to the intervention, Project QuEST, and two sections were randomly assigned to the district curriculum. Treatment effects were tested separately for science knowledge and vocabulary using a three-level multi-level analysis of covariance (students nested within section, sections nested within teacher, and teacher) with the analogous pretest serving as the covariate. Analyses included fixed effects of treatment assignment and the covariate. Treatment effects were tested at the level of the section. Results indicated that posttest differences favoring the treatment group sections were statistically significant for both science knowledge and vocabulary.

Project QuEST makes an important contribution to the field in that there is very little research that explores whether enhancements to traditional practices are necessary or improve the traditional versions, and importantly, whether modifications to traditional practices to make them more effective with English learners also make them more effective with monolingual English students. To be optimal, ESL-enhanced instructional practices must enhance the learning of English learners in the classroom *and* must be no less effective than traditional methods of instruction for monolingual English students. Because English learner students are often placed in classrooms with native speakers of English, it is critical that the development of instructional methods to specifically benefit the English learners in mixed classrooms not disadvantage those students in the same classrooms who are not identified as English learners. The recent study of QuEST indicated that such instructional improvements are not merely theoretically possible, they can be achieved in real school settings with actual middle school science teachers.

While much work remains to be done, to our knowledge this study represents the first such demonstration in a randomized controlled experiment that gains in content area knowledge in science and vocabulary are possible for both English learners and English-proficient student using a common approach to instruction that is designed to be optimal for the English learners. Of all research published between 1982 and 2009 about English learners in settings where English is the main medium of science instruction in elementary and secondary schools, this is only published experimental study we know of that has found significant intervention effects for both English learners and English-proficient students in science knowledge and science vocabulary.

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