REGION IX EQUITY ASSISTANCE CENTER AT WestEd

High-Quality Science Instruction

Building Conceptual Understanding and Language Skills for English Learners

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The confluence of three current education movements—21st century skills, the *Common Core State Standards* (*CCSS*), and the *Next Generation Science Standards* (*NGSS*)—provides an unparalleled opportunity to improve science, technology, engineering, and mathematics (STEM) education for *all* students, particularly English learners. These three movements point to a significant shift in education toward a deeper approach to learning—an approach that focuses on building both conceptual understanding and the language skills necessary to convey that understanding. This paper supports the idea that high-quality science instruction serves as an effective method to achieve these goals; it focuses on the importance of implementing high-quality science lessons that build both conceptual understanding and language skills for all students, particularly English learners.

To provide a broad context on the current state of STEM education, we begin with an overview of 21st century skills, *CCSS*, and *NGSS*—and what these mean for student learning, particularly related to language development. Next, we discuss how high-quality science lessons can effectively support language development, especially for English learners. Finally, we describe a professional learning project that enabled teachers in Montebello Unified School District to develop lesson plans for teaching science concepts and correlating language skills.

21st century skills, Common Core State Standards, and Next Generation Science Standards

The education and corporate sectors are increasingly promoting 21st century skills that can help build a workforce that is technology and information literate, creative, and innovative—one that can problem solve, make decisions, and work collaboratively. This emphasis on 21st century skills establishes a foundation for a deeper, more interactive type of teaching and learning than has been the norm in the No Child Left Behind environment, which often resulted in an increase in rote learning. In addition, the *Common Core State Standards for English Language Arts* [*CCSS ELA*] *& Literacy in History/Social Studies, Science, and Technical Subjects* and the *Common Core State Standards for Mathematics* (*CCSS Mathematics*), call for students to be career and college ready by the end of their high school education. Accordingly, these standards focus on a complex command of language and content skills, knowledge, and abilities, as well as the application of learning to real-world events. Finally, the recently released *Next Generation Science Standards* (*NGSS*) call for students to understand core ideas in the disciplines of life, earth, and physical science, as well as engineering and technology. The *NGSS* recognize the cross-cutting concepts that unite these disciplines. Importantly, the *NGSS* also expect students to implement the practices of science and engineering—practices that form the foundation of many 21st century skills and which align with the practices embedded in the *CCSS*.

The synergy of these three movements signals a fundamental shift in education toward a deeper approach to learning to enable students to be career and college ready. As Linda Darling-Hammond, Charles E. Ducommun Professor of Education at Stanford University, states, "Simply remembering [the knowledge] you're taught no longer works in today's world. Students must also learn to learn—to understand the meaning and purpose of a concept or idea and apply it to solving a problem" (*REL West Research Digest*, 2012, p. 1).

While previous standards were often knowledge-based (e.g., "students will know . . ."), the *CCSS* and the *NGSS* explicitly promote the language skills necessary to communicate knowledge. For instance, the *CCSS Mathematics* indicate that students should be able to use stated assumptions, definitions, and previously established results in constructing arguments. Furthermore, in the *CCSS ELA Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects,* students are asked to make claims supported with evidence from multiple source; and in the *NGSS*, students are asked to obtain, evaluate, and communicate information. All of these standards promote student involvement in discipline-specific, language-rich tasks.

This paradigm shift in the standards toward promoting effective language and communication skills, in addition to content knowledge, is especially important for English learners—a population that continues to grow nationally. In California, for example, 41 percent of students are or have been classified as linguistic minority students (Linquanti & Hakuta, 2012). Hakuta (2013) describes the CCSS as a fresh opportunity to promote high achievement among English learners because the standards "raise the bar for learning, raise the demand for language, and call for a high level of classroom discourse across all subject areas" (slide 13). California's new *English Language Development Standards for California Public Schools, Kindergarten Through Grade Twelve* (CDE, 2012) (California's *ELD Standards*), resonate with the opportunities described by Hakuta. California's ELD standards are not intended to replace the *CCSS ELA*. Instead, they are intended to further promote the language knowledge, skills, and abilities that English learners must acquire in order to develop English proficiency and succeed in school.

For English learners to benefit from this shift in emphasis of learning, teachers must provide students with the necessary discipline-based language skills to interpret what is spoken and read, interact with adults and peers, and present their knowledge and thinking to others. In other words, teachers must enable their students to effectively use language in academic settings (Quinn, Valdes, & Lee, in press). The overview of California's *ELD Standards* emphasizes that English learners at all proficiency levels are capable of high-level thinking and can engage in complex, cognitively demanding social and academic activities that require English—as long as they receive appropriate linguistic support. The extent of support that students need varies depending on the familiarity and complexity of the task or topic, as well as on the students' English language proficiency level.

How science can promote language learning

21st century skills, the *Common Core State Standards*, and the *Next Generation Science Standards* all call for students to engage in "real-world" learning. And science, with its connections to the natural world and hands-on experimentation, provides a rich context for developing academic English language skills. Scientists strive to find cause-and-effect relationships within the natural world and make evidence-based claims to describe and defend those relationships. Accordingly, science writing often involves procedural language, highly technical terms, and objective evidence to draw conclusions. Science writing also often includes charts, diagrams, and graphs to display data. Using evidence-based scientific argument is central to both oral and written communication in science. The language of science involves a wide range of conceptual understanding that is grounded in experimentation, writing, and reading, all of which build academic language that enhances student understanding.

High-quality science lessons have components that effectively support the needs of English learners. For example, effective inquiry-based science lessons consider the type and sequence of learning activities that move students from their prior knowledge to the intended conceptual learning. These learning activities are structured as "hands-on, minds-on" activities in which students engage in tasks that incorporate manipulatives or realia to promote student thinking about the specific science concept. Learning activities with manipulatives include designing picture cards, building models, observing real or artificial artifacts, or conducting scientific experiments. Manipulatives can reduce the learners' language load, providing concrete contextual clues for the language necessary to engage in learning and concept development.

In addition, effective science learning activities are designed to be open enough to allow for more than one way of thinking or one path of investigation. These activities encourage expressive language—both social and academic—if they are designed for students to collaborate and build their understanding through shared discussions. This type of collaborative conversation is particularly helpful for the linguistic development of English learners. Teachers, listening to students' discourse, can make instructional decisions based on what students express in terms of both content and language proficiency. In these types of group-learning activities, students learn science concepts and language skills from their peers, since students often use language that is more accessible than a teacher's language (Shea, Shanahan, Gomez-Zwiep, & Straits, in press).

Additionally, science lessons can be structured to promote purposeful dialogue. Rich conversations do not just occur—language objectives, like science objectives, must be identified, and learning experiences must be orchestrated to enable students to understand science and gain language. Careful attention to science and language strategies increases the opportunities for English learners to learn and apply academic language.

Montebello Unified School District: Developing lessons that teach science concepts *and* build language skills

Through an Improving Teacher Quality Grant from the California Postsecondary Education Commission, WestEd's K–12 Alliance—in conjunction with California State University, Long Beach, and the Montebello Unified School District—developed and implemented a science and English academic language program at three elementary schools that had high populations of English learners and low-income students. This project enabled the Montebello teachers to develop inquiry-based elementary science lessons that provided rich science learning and that supported the language needs of English learners. As a discipline, science can be an effective vehicle for supporting language development because "inquiry science provides a highly contexualized setting for authentic language uses . . . [and] it allows opportunity to develop higher level thinking and opportunities to dialogue without being text or print dependent" (Gomez-Zwiep, Straits, Stone, Beltran, & Furtado, 2011, p. 774).

Designing lessons focused on science concepts

The strategies developed by the professional development providers in the Montebello project support the idea that content learning and language development are inextricably linked. The project identified meaningful and engaging activities designed to build content knowledge before strategically delving into specifics about how language is structured. With this focus, the strategies used in this project matched the sequence of California's *ELD Standards*, which are organized to initially focus on content meaning and interaction, and then focus on knowledge about the English language and how it works.

The Montebello professional development project strategically built on the 5E Instructional Model (Bybee, 1997; Bybee et al., 2006), which many science educators use. In this inquiry-based instructional model, lessons are designed around five stages, each beginning with an "E": (1) *Engage*—students reveal their prior knowledge; (2) *Explore*—students explore new phenomena; (3) *Explain*—students construct an explanation for their thinking; (4) *Elaborate*—students apply their understanding in new areas; and (5) *Evaluate*—students reveal their thinking as they move from prior knowledge to understanding the lesson's concept. The 5E Instructional Model uses a lesson design planning template, which requires teachers to think about their activities and discussion prompts, while being mindful of student responses. For Montebello's program, WestEd's K–12 Alliance modified the 5E planning template to include a "concept" column to help teachers keep their lessons' conceptual flow in mind as they planned activities for student learning. The Montebello teachers also included the *Evaluate* phase in every stage as a way to monitor and assess student understanding. Figure 1 is the modified 5E lesson design planning template used in Montebello.

Figure 1: Modified 5E lesson design planning template

Concept	Teacher	Student
Engage **(prior-knowledge concept)**		***Evaluate***
Explore **(connect prior-knowledge concept to lesson concept)**		***Evaluate***
Explain **(lesson concept to be understood)**		***Evaluate***
Elaborate **(concept to be applied)**		***Evaluate***

Source: Adapted from 5E lesson design planning template (Bybee, 1997).

Using a form of backward design (DiRanna et al., 2008), the Montebello teachers began their lesson designs by completing the "concept" column and mapping the concepts that students should ultimately learn and be able to perform or explain. First, the teachers considered what concepts students should possess as prior knowledge for the lesson. Next, they considered the concepts students should explore to connect their prior knowledge with the lesson concept. Last, the teachers considered what concepts the students should apply in order to demonstrate their understanding of the concept.

The Montebello teachers then considered the "student" column. They clarified how students would communicate their understanding of the concept through drawings, writing, or verbal communication. Teachers were encouraged to use a variety of assessments (e.g., graphic organizers, drawings, writing activities, manipulatives) for all learners.

Finally, the Montebello teachers completed the "teacher" column with discussion prompts, questions, and activities designed to elicit specific student thinking and understanding. The completion of this column generally became a "zigzag dance" between the teacher and student columns—as teachers completed their prompts, they anticipated the correlating types of student responses and entered those into the student column. The teachers were encouraged to anticipate what a high-level response might be, as well as misconceptions that might be revealed. Identifying these expected student responses allowed teachers, at the end of each phase of the 5E cycle, to decide if students were developing understandings of the concepts as intended, or if the lesson needed to be modified before moving forward, based on the expected student responses.

Designing lessons that support language development

Once the Montebello teachers mapped out their lesson plans for teaching particular science concepts, they focused on explicitly integrating language development into their lesson designs. Gomez-Zwiep et al. (2011) explain that this phase of planning—focused on language-development goals—is the most important in terms of considering the needs of English learners. Many of the natural functions of language align with scientific processes, such as questioning, describing, clarifying, and comparing. Accordingly, during this planning phase, the teachers had to determine for each "E" stage how language would be used for specific purposes.

To help focus the teachers' attention on explicitly incorporating language skills into science lessons, the Montebello project further modified the 5E template to include a column for the language function that correlated with the particular concept(s) identified in each "E" stage (Figure 2). Accordingly, the teachers were asked to identify the major language focus of each phase of the lesson and add it to the concept/language column. For example, in the *Engage* phase, students might be asked to use language to *describe* a concept, while in the *Explore* and *Explain* phases, students might be asked to use language to *compare and contrast* and to *classify* concepts. In the *Elaborate* phase, students might be asked to *classify* a concept *with justification* (see Figure 2).

Figure 2: Modified 5E lesson design planning template, with language component

Concept/language	Teacher	Student
Engage **Use describe to elicit the prior-knowledge concept.**		***Evaluate***
Explore **Use compare and contrast to connect the explore concept with the prior-knowledge concept and the lesson concept.**		***Evaluate***
Explain **Use classify using compare and contrast to explain the lesson concept.**		***Evaluate***
Elaborate **Use classify with justification to apply the elaborate concept.**		***Evaluate***

Source: Adapted from 5E lesson design planning template (Bybee, 1997).

Because vocabulary is important for building academic language, the Montebello teachers learned to distinguish between *Tier 1* words (Beck, McKeown, & Kucan, 2002)—which are basic, everyday words that, outside of direct language instruction, are not typically emphasized in instruction—and *embedded* vocabulary, which emerges from the lesson. In science, Tier 1 words should be front-loaded, or taught before the science lesson, to give English learners a basic foundation with which to engage in the lesson and to participate actively in the *Explore* phase. After the Montebello teachers identified the *Tier 1* words, they identified the *embedded* vocabulary to be used in the *Explore* and *Explain* phases. For example, front-loaded *Tier 1* words might include the names of the objects to be studied and some descriptors of those objects, while *embedded* terms that convey scientific meaning, such as density, opaque, and mass, are taught in the lesson's context.

The Montebello teachers also learned how to strategically integrate graphic organizers into lessons, not only for organizing science learning, but as a way to help English learners interact with new vocabulary and connect ideas as they build conceptual frameworks. In addition, the teachers learned to develop sentence frames to help their students effectively communicate scientific ideas in written English. Once the teachers identified the primary language function for each phase of the lesson, they created correlating sentence frames to reinforce the grammatical structures that their students should be using to communicate their ideas. For instance, if students were expected to make a prediction, the teachers provided a sentence frame, such as "I think _____ because _____." Teachers also used "word walls," that is, posting academic vocabulary from the lesson on a classroom wall for convenient student access in discussions and writing. Sentence frames, graphic organizers, and vocabulary were added by the teachers to the teacher column of the lesson design template, with appropriate student responses designated in the student column.

In general, when integrating these language development strategies into lessons, teachers should structure them to meet the correlating proficiency level of their English learners, as identified in California's ELD Proficiency Level Descriptors (i.e., emerging, expanding, and bridging). However, while the Proficiency Level Descriptors describe an aligned set of knowledge, skills, and abilities at each proficiency level—reflecting a linear progression across the levels—these designations are made for purposes of presentation and understanding. Actual second-language acquisition does not necessarily occur in a linear fashion within or across proficiency levels. According to California's *ELD Standards*, a proficiency level does not identify a student; rather, the proficiency level identifies what a student knows and can do at a particular stage of English language development. For instance, it would not be accurate to state that a teacher has an "emerging student," but it would be accurate to state that a teacher has a "student whose listening comprehension ability is at the emerging level."

Conclusion

Insights gained from the Montebello project can inform other educators who need to make science instruction comprehensible and increase opportunities for language development, particularly for English learners. One insight gained was that teachers recognized that English learners needed various types of language supports to help them express their new science knowledge. For example, the teachers learned that while sentence frames helped students communicate their findings, the frames also often limited student responses, resulting in student work that did not reflect the range of student conceptual understanding that typically exists across groups of students in a class.

The teachers realized that they needed additional level-appropriate language strategies to increase student understanding, "such as providing realia or pictures and asking students to make concrete observations, to physically manipulate materials, or to draw one or a sequence of diagrams to express their thinking" (Gomez-Zwiep et al., 2011, p. 778).

The Montebello project provides a model for professional learning by identifying resources and methodologies that assist teachers in designing lessons that engage English learners in intellectually challenging literacy- and discipline-specific tasks. Through inquiry-based science, students use language in meaningful and relevant ways to attain and communicate information and ideas and to apply linguistic knowledge to academic tasks. Science provides a vehicle for all students to achieve and use 21st century skills as they understand and apply the *CCSS* and *NGSS* to real-world situations. Most importantly, in an inquiry-based science classroom, English learners join their student colleagues in understanding and communicating the ways in which the natural world operates, and in taking pleasure in being part of that world.

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