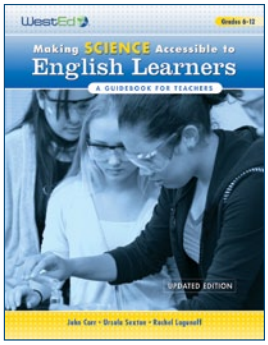

Chapter 1 — Teaching Science

from Making Science Accessible to English Learners: A Guidebook for Teachers, Grades 6–12 (Updated Edition)

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CHAPTER 1

Teaching Science

This chapter offers an overview of science pedagogy applied to English learners, beginning with principles of learning and motivation that apply to all learners. We review the 5 Es instructional model proposed over a decade ago by Roger W. Bybee[1] not only because it is widely respected, but especially because its highly contextualized format allows students to participate fully even though they may be at different levels of science and English literacy. Along with the 5 Es approach, we discuss how three common modes of teaching can benefit English learners, and we introduce the first of many specific strategies to differentiate science instruction for English learners.

PRINCIPLES OF LEARNING AND MOTIVATION

Regardless of whether students are native English speakers or English learners, three research-based principles about how people learn[2] guide effective science teaching and learning. These principles are the foundation of all of the ideas and strategies presented in this guidebook. Making science accessible to English learners means, first of all, recognizing how any student learns.

Principle 1. Students come to the classroom with preconceptions about how the world works. If their initial understanding is not engaged, they may fail to grasp the new concepts and information that are taught, or they may learn them for purposes of a test but revert to their preconceptions outside the classroom.

English learners, like any learners, need a way to connect what they know with what they need to learn.

Principle 2. To develop competence in an area of inquiry, students must (a) have a deep foundation of factual knowledge, (b) understand facts and ideas in the context of a conceptual framework, and (c) organize knowledge in ways that facilitate retrieval and application.

English learners, like any learners, need to learn facts and ideas and need to be able to relate and organize them conceptually.

Principle 3. A metacognitive approach to instruction can help students learn to take control of their own learning by defining learning goals and monitoring their progress in achieving them.

English learners, like any learners, benefit from reflecting on their learning goals and progress. English learners, unlike native English speakers, will need to apply a metacognitive approach to learning English as well as to learning discipline-specific content — in this case, science content.

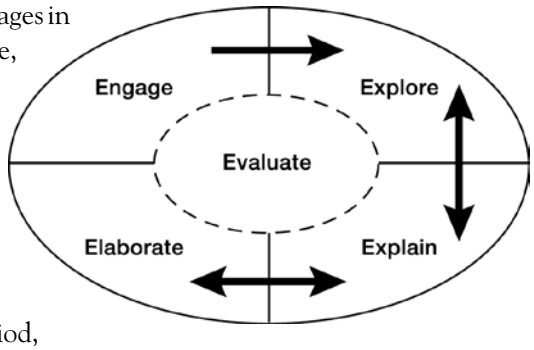
The artful teacher brings these principles to life for each student, recognizing a student's current level of knowledge and understanding and facilitating each student's growth as a self-directed learner. A respectful classroom climate is key to a teacher's success in being able to do this. Often a visitor can step into a classroom and feel a distinct climate, whether of respect and caring, fear of ridicule, or boredom and detachment. A positive climate is established by teacher modeling and facilitation and is sustained by student practice.

In a safe learning community, because students are patient with one another and do not laugh at mistakes, they can all relax. With their anxiety lowered, students are physiologically more able to accept new challenges and grapple with new concepts and problems.[3] Because English learners can be expected to feel high levels of anxiety about all the challenges they face, it is especially important for them to feel respected by the teacher and other students, whether they are struggling to learn English and science or to communicate different cultural and religious perspectives they may bring to discussions.

Within inclusive classrooms, educators increasingly recognize that equal and equitable are not synonymous.[4] Widespread interest in differentiating instruction reflects the understanding that students learn in different ways, but they do learn. Providing a high-quality science education for all students means planning and using strategies that fit diverse students.

THE 5 Es MODEL OF TEACHING AND LEARNING SCIENCE

The 5 Es model represents a recursive cycle of cognitive stages in inquiry-based learning: engage, explore, explain, elaborate, and evaluate. As the arrows in the figure to the right denote, the stages are not necessarily linear; there may well be back and forth progression between stages, especially between explore and explain and between explain and elaborate. The evaluate stage crosses into the other four as students continually reflect on what they do and do not know. Typically, not all five stages would be experienced in a single classroom period, but all five would certainly be embedded in a lesson or unit lasting days or weeks.



Based on constructivist learning theory, the 5 Es approach capitalizes on hands-on activities, students' curiosity, and academic discussion among students. It should be a key part of all students' science education, explicitly connected to target concepts and content standards and used in conjunction with other methods, including direct instruction.

The following descriptors[5] of the 5 E stages are complemented by excerpts from an account[6] of a teacher's vision for implementing each stage in the classroom. Figure 1.1 presents yet another way to understand the 5 Es, with teacher and student roles delineated.

Engage

The teacher starts the learning process by involving students in making connections between their past and present learning experiences. This stage is meant to create interest, generate curiosity, and raise questions and problems, helping students engage in their own learning process while facilitating opportunities for the teacher to identify students' misconceptions. Any activity a teacher might use to engage students should be explicitly connected to content and standards in the unit lesson.

> **In my classroom . . .** I begin my lesson plan with an intriguing idea, image, or question to engage students. I pose questions about what my students already know, and students pose questions about what they want to learn. It alerts me to misconceptions.

Explore

The teacher guides students as they investigate or perform an experiment about a phenomenon and arrive at a common understanding of certain concepts, processes, and skills. The teacher designs activities that encourage students to construct new knowledge or skills, propose preliminary predictions and hypotheses, "puzzle" through problems, and try alternatives to solve a problem.

> **In my classroom . . .** I do not tell students the concepts I want them to eventually know. Instead, I expect them to think critically about the concepts by experimenting, investigating, observing, classifying, communicating, measuring, predicting, and interpreting. This active engagement arouses curiosity and leads students to discover new ideas, confirm prior assumptions, or perhaps challenge their thinking.

Explain

The teacher guides students as they demonstrate or explain their conceptual understanding, process skills, or behaviors. They debate alternative explanations and contrast new facts with prior misconceptions. As appropriate, the teacher directs their attention to aspects of their earlier "engage" and "explore" experiences. Students organize information into evidence-based statements, using the academic language of science.

> **In my classroom . . .** I guide students' thinking by questioning and facilitating peer discussions to arrive at explanations for scientific phenomena. I give students time to think, and I facilitate student–student discussions to correct misconceptions. It is a time to question and justify answers. Students do not just pose questions and I answer, nor do they simply give answers and I decide what is right or wrong.

Elaborate

The teacher monitors activities and facilitates discussions that challenge and extend students' conceptual understanding and skills. Students apply what they learned to new experiences to develop, extend, connect, and deepen their understanding.

> **In my classroom . . .** I help students compare, contrast, combine, synthesize, generalize, and make inferences by introducing a somewhat different context from what they just experienced. I want students to apply new knowledge, make connections, and extend ideas.

FIGURE 1.1. **The 5 Es Instructional Model**

Purpose	Teacher Role	Student Role
Engage		
To initiate the lesson An engagement activity connects past and present learning experiences, anticipates new ideas, and organizes students' thinking toward standards and outcomes.	» create interest » generate curiosity » raise questions and problems » elicit responses that uncover students' current knowledge about the concept/topic	» ask questions such as "Why did this happen?" "What do I already know about this?" "What can I find out about this?" "How can this problem be solved?" » show interest in the topic
Explore		
To provide students with a common base of experiences within which current concepts, processes, and skills are identified and developed	» guide students to work together without direct instruction » observe and listen to students as they interact » ask probing questions to redirect students' investigations as needed » provide time for students to puzzle through problems » act as a consultant for students	» think creatively within the limits of the activity » test predictions and hypotheses » form new predictions and hypotheses » try alternatives to solve a problem and discuss them with others » record observations and ideas » suspend judgment » test ideas
Explain		
To focus students on a particular aspect of their prior stage experiences This stage provides opportunities for students to demonstrate their conceptual understanding and process skills. This stage may be an opportunity to introduce a concept, process, or skill.	» guide students to explain concepts and definitions in their own words » ask for justification (evidence) and clarification from students » formally provide definitions, explanations, and new vocabulary » use students' previous experiences as the basis for explaining concepts	» explain possible solutions or answers to other students » listen critically to and question respectfully other students' explanations » listen and try to comprehend explanations offered by the teacher » refer to previous activities

FIGURE 1.1. **The 5 Es Instructional Model (continued)**

Purpose	Teacher Role	Student Role
Elaborate		
To challenge and extend students' conceptual understanding and skills Through new experiences, students develop deeper and broader understanding, more information, and adequate skills.	» expect students to use learned academic language in a new context » encourage students to apply the concepts and skills in new situations » remind students of alternative explanations » refer students to alternative explanations	» apply new labels, definitions, explanations, and skills in new but connected situations » use previous information to ask questions, propose solutions, make decisions, and design experiments » draw reasonable conclusions from evidence » record observations or explanations
Evaluate		
To encourage students to assess their understanding and abilities and to provide opportunities for teachers to evaluate student progress	» refer students to existing data and evidence and ask, "What do you already know?" "Why do you think…?" » observe students as they apply new concepts and skills » assess students' knowledge/skills » look for evidence that students have changed their thinking » ask students to assess their learning and group process skills » ask open-ended questions such as "What evidence do you have?" "What do you know about the problem?"	» check for understanding among peers » answer open-ended questions by using observations, evidence, and previously accepted explanations » demonstrate an understanding or knowledge of the concept or skill » evaluate own progress and knowledge » ask related questions that would encourage future investigations

Source: R.W. Bybee (1997). *Achieving scientific literacy: From purposes to practices*. Portsmouth, NH: Heinemann. Adapted with permission.

Evaluate

The teacher evaluates students' progress and students assess themselves throughout the other stages. Feedback may come from checking for understanding (e.g., with hand gestures, white boards), quizzes, student discussions, or journals, to name a few techniques. The teacher uses the feedback to reflect on the effectiveness of the lesson, making midcourse adjustments as indicated to better fit the needs and interests of students. The students use the feedback to reflect on what they understand and what they still need to learn or want to know next.

> **In my classroom . . .** I test more than factual knowledge; I challenge students to construct ideas and explanations during an assessment. I want students to construct knowledge and build skills during instruction, and I want assessments to reflect my objectives and the content standards.

Throughout the 5 Es cycle, the role of the teacher is multifaceted. As a facilitator, the teacher nurtures creative thinking, problem solving, interaction, communication, and discovery. As a model, the teacher initiates thinking processes, inspires positive attitudes toward learning, motivates, and demonstrates skill-building techniques. Finally, as a guide, the teacher helps to bridge language gaps and foster individuality, collaboration, and personal growth. The teacher flows in and out of these various roles within each lesson, both as planned and as opportunities arise.

Part of this flow can be captured by the three modes of instruction that describe the participatory roles of the teacher and students. How to use these modes in interaction with the 5 Es and to address the special needs of English learners is discussed below. Figure 1.2 is a simple matrix of the most common combinations of the 5 E stages and three modes of instruction.

FIGURE 1.2. **Common Combinations of 5 E Stages and Modes of Instruction**

	Participatory Mode of Instruction		
5 Es STAGE	**Teacher-Directed**	**Teacher-Assisted**	**Peer-Assisted**
Engage	●		
Explore			●
Explain		●	●
Elaborate		●	●
Evaluate	●	●	●

THREE MODES OF INSTRUCTION APPLIED TO ENGLISH LEARNERS

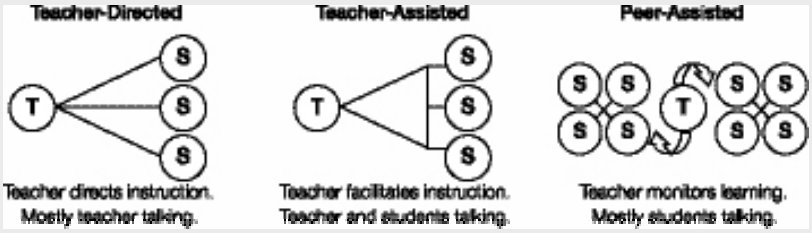
All teachers commonly mix three modes of instruction — teacher-directed, teacher-assisted, and peer-assisted — throughout their lessons (see figure 1.3). In a science classroom, different modes present different benefits and opportunities for students. For the English learners in a classroom, special considerations can improve the effectiveness of each of these modes.

Teacher-directed. English learners will feel comfortable in teacher-directed instruction when the teacher provides comprehensible input, using language and speech students can understand, supported with visuals and demonstrations.

Teacher-assisted. English learners will feel more comfortable speaking in teacher-assisted conversations when the teacher establishes a risk-free, caring climate and encourages responses at students' level of comprehending input and producing meaningful output.

Peer-assisted. English learners will feel comfortable in peer-assisted instruction when respected and supported by peers in the group and when group tasks are within their communication capabilities. Peer-assisted instruction is an opportunity for English learners to use their native academic language (if grouped by same language) and to participate as English listeners and speakers as key concepts are repeated and rephrased in English during the whole class discussion.

FIGURE 1.3. **Three Modes of Instruction**



Teacher-Directed Instruction

In teacher-directed instruction, the teacher provides direct instruction to the whole class and individual students respond to the teacher; most interactions are teacher–student. The teacher initiates concept development by giving direct instruction, demonstrating to the whole class, and modeling specific scientific protocols and expected behaviors and processes. The teacher combines saying with showing—supporting oral instruction with pictures, illustrations, realia, graphic organizers, models, demonstrations, video clips, and other visuals. Teacher-directed instruction gives students access to the information they need to begin processing and manipulating ideas, safely use instruments, clarify concepts, and help build connections that facilitate greater understanding of science.

APPLICATIONS FOR ENGLISH LEARNERS

Teacher modeling is an important support for English learners. English learners need to see completed projects and writing assignments; some students may never have had formal schooling or participated in similar tasks in their former countries. Also, before students engage in teacher-assisted discussions and peer-assisted learning activities, the teacher needs to model expected social behaviors and procedures.

When speaking, the teacher can target the listening abilities of English learners in terms of enunciation, speed, intonation, and use of vocabulary, idioms, and contractions. With English learners who are at novice levels, simple subject-verb-object sentences free of idioms and colloquial expressions are necessary. (It can be surprising how many expressions such as "no way," or "make up your mind," or even "take a seat" pepper typical classroom instruction, to the befuddlement of English learners.)

For the benefit of English learners as well as other students, all teacher-directed interactions should be divided into chunks no longer than 15 minutes. Students need time to process each chunk before encountering another chunk.[7] This processing involves relating new information to prior knowledge and experiences, confronting any prior misunderstandings, and constructing new understandings. English learners may also need extra time to listen in English, think in their primary language, and translate their thinking back into English. In some instances they may also want to discuss unknown English vocabulary and new science concepts with another speaker of their primary language.

Between chunks of presented material and information, the teacher checks for understanding. Research indicates that learning improves for the whole class and the achievement gap narrows when

the teacher uses techniques to get feedback about each student's understanding during direct instruction and immediately makes appropriate adjustments.[8]

Calling on individual students is a way to collect feedback from a few students at a time. Alternative ways to check for understanding can provide broader information and encourage all students to respond:

- Students use white boards to write and display short answers.
- Students signal agreement/disagreement/confusion with a point of view, solution, or approach using colored cards or hand gestures.
- Students answer chorally.
- Students work in teams to respond. For example, teams contribute to a collective class solution to a problem; partners talk with one another in English or their primary language before reporting to the class in English.

When asking a question of the whole class, the teacher waits several seconds so that all students have ample opportunity to process the question and think about an answer (three to seven seconds depending on the difficulty of the question). The teacher may acknowledge early "hand raisers" with a nod while still waiting to give everyone time to think of an answer. Wait time allows English learners to decipher the question, think, and formulate an answer in English. It also encourages more students to respond. To resist the urge to keep the lesson pace moving rapidly, the teacher may use a technique such as counting silently or pacing the floor one step per second. When students are called on, walking close to the student being questioned may lessen the student's anxiety about speaking in front of many peers. For English learners, hearing other students rephrase information provides additional opportunities to learn science vocabulary and comprehend important ideas.

Teacher-Assisted Instruction

In teacher-assisted instruction, the teacher guides brainstorming and discussion among the whole class; interaction is student–student and teacher–student. Think-pair-share is an example, with pairs of students quickly sharing an idea based on the teacher's question, and the teacher then facilitating whole group sharing and discussion.

In this mode, the teacher does not lecture and give answers. When a student asks a question, other students respond rather than the teacher. Small groups or the whole class agree that an answer is correct, appropriate, or applicable based on supporting evidence and reasoning. Teacher-assisted instruction empowers and guides students to think and talk as scientist apprentices. Through thoughtful questioning techniques, the teacher facilitates and probes to encourage critical thinking, responds to student questions with meaningful questions that engage them in further dialogue with each other and with the teacher, and promotes the revision or review of their interpretations based on the evidence at hand. As students construct meaning from their explorations and text, the teacher may deem it necessary to intervene — by providing further evidence, raw data, or other resources or interactions — so as to model closer examination of evidence to correct misconceptions. The teacher should be aware that some students may need to interpret information that appears to contradict deeply held beliefs learned at home or

in their communities. By providing a safe environment in which to express ideas, the teacher allows students to accommodate interpretations or test new ideas, while continuing to build understanding based on empirical and quantitative evidence.

APPLICATIONS FOR ENGLISH LEARNERS

The teacher ensures that English learners can participate in a variety of ways. First, the teacher frequently combines visuals, such as word walls, with "teacher talk," emphasizing key words and concepts. English learners can glance at word walls to "pull" words they want to incorporate when answering questions or participating in class discussions. Second, the teacher uses controlled speech, tailoring the wording of some questions for novice English learners and some for intermediate and more advanced English learners. Differentiated questioning gives all students the opportunity to participate in class discussions.

When an English learner student responds (and the answer is acceptable), the teacher may use "scientific rephrasing" to clarify the idea for all students and model desired academic discourse. The rephrasing is most helpful to the English learner if it is at a level just above what the student produced independently. The student might repeat the teacher's "rephrased statement" but should not be overtly asked to do so. For all students, scientific rephrasing helps them gradually develop much more sophisticated academic discourse. This can happen in a safe, respectful environment. Additionally, English learners have greater opportunity to comprehend concepts and thought processes when much of the class discussion involves redundancy among students. For instance, students may be invited to indicate agreement by restating the teacher's or another student's statement.

In teacher-assisted instruction, before individual students are asked to reply, the teacher may use think-pair-share, giving students a minute to think, then a minute or so to share answers with a partner before beginning a whole class discussion. This allows English learners to say their ideas comfortably with a partner before "going public" in front of the class. Think-pair-share is another way to build in redundancy, allowing English learners to hear an important concept described in slightly different ways, first in pairs and then in a whole class discussion.

Peer-Assisted Instruction

In peer-assisted instruction, small groups of students interact and learn as a team through collaborative or cooperative activities. Before students begin complex group activities, the teacher may need to model the expected group learning behaviors and establish rules of conduct. Students teach each other and learn together while the teacher monitors, guides, and models as necessary.

APPLICATIONS FOR ENGLISH LEARNERS

Some basic steps prepare students to work effectively in teams or small groups and ensure that English learners will be able to participate and learn. The teacher who designs effective cooperative and collaborative activities makes sure that an activity is cognitively challenging for everyone while varying the language demands that are necessary to participate and contribute. The activity itself will be structured in such a way that necessitates collaboration and discussion.

By making sure the group work directions and expectations are clear, the teacher also clears the way for a focus on learning. In classrooms with English learners, directions should be written as well as oral. For the teacher, writing the directions before giving them orally is also an opportunity to check that they are clear.

Sometimes student groups misbehave or become passive because they do not understand the concepts or the task instructions, so the teacher may need to initiate group work by modeling expected behaviors and gradually shift ownership of the group learning process to the students. Assigning roles is one way to help groups manage their interactions and structure successful participation for everyone. For example, a novice English learner in a group could participate as the illustrator of key concepts while more English proficient students are assigned to act as facilitator, writer, or reporter. With more experience and success, students can choose their own roles or collaborate more interdependently.

The grouping decisions a teacher makes should be strategic, sometimes grouping English learners by primary language, sometimes including them in groups with no other English learners, sometimes grouping students by other characteristics, and sometimes allowing students to choose groups by topic or interest. In a classroom where a strong community has been established, students might sometimes be allowed to choose groups by friendship, so long as everyone understands that no students must feel unwanted. (Figure 1.4 is one teacher's description of the grouping decisions she makes in a classroom where most students are English learners.)

FIGURE 1.4. One Teacher's Grouping Decisions

Following is a brief scenario of a high school science classroom where the teacher shifts among teacher-directed, teacher-assisted, and peer-assisted instruction.[9] This scenario shows the advantages of grouping students by their primary language. Other grouping criteria should be used as well (e.g., social characteristics, topic choice, science literacy).

Classroom setting. I speak only English and I have 35 students in my class, most of whom are English learners, spanning five languages (Spanish, Vietnamese, Mandarin, Tagalog, and Russian). There are eight lab stations in the room.

Grouping. Often I plan flexible student groupings for lab activities, mixing students by primary language, English literacy, and/or science literacy. Other times I allow students to select their own groups, and they usually select friends who speak their language. Today, I allow students to self-select, and most do so by their primary language. One station has Mandarin speakers, another Vietnamese, another Tagalog, two have Spanish speakers, and one station has native English speakers. My single Russian speaker sits with the English speakers.

Modeling. For this lesson, I start by conducting an experiment in front of the class. As we summarize each step of the experiment, I fill in key words on a graphic organizer on the board. (Soon in the year I will shift and just give procedural directions, students will initiate group experiments, and we will conclude with a class discussion in English that incorporates visuals such as graphic organizers.)

Group learning. Then students conduct the same experiment at their lab stations. They discuss in whichever language they choose, take notes about what they observe, and make illustrations. I have given English learners prepared notes with sentence frames (three levels of support corresponding to three levels of English proficiency). I walk around to answer questions and ensure that they are all learning successfully. Later, when I model the English responses to the questions, all students — even the most recently immigrated English learners — must write in English. Discussions within the self-selected groups of English learners are typically a mix of English and primary language, depending on the group members' needs and comfort levels. Later, when we have the full class discussion in English, the most limited English proficient learners will have a good idea of what is being said because it was first discussed within the homogeneous language group. For example, a new student will have spoken only Vietnamese while more proficient English learners discussed concepts in English with a little Vietnamese thrown in. If the new student didn't seem to understand, another Vietnamese speaker would have explained in Vietnamese.

The advantage to having students use their language of choice for peer-assisted learning and problem solving is that the focus stays on the science content. Students are not inhibited by their variable ability to communicate in English, so I feel more comfortable that they can really understand the concepts in the day's experiment.

Discussing. Next, I lead a whole class discussion in English about what they observed. I use the same structured format every time: (1) What did you do? (2) What did you observe happening? and (3) Why did it happen? I write students' answers as English sentences on an overhead transparency projected so that they all can see. Students copy the sentences in their notebooks in English and make connections to their lab notes. I find that repetition of common questions helps orient my English learners and provides a familiar context.

My newest student, who is at the beginning English learner level, benefits from listening to good oral models about content that is both familiar and meaningful, although I do not expect him to fully comprehend all that other students are saying. I assist other English learners to communicate their ideas by providing vocabulary, cues, and other structures that help them convey their thinking. The more proficient the English learner, the more elaborate I expect his or her comments to be. I do not ask "dumbed-down" questions, but I do adjust questions to be comprehensible for my English learners. When they finish responding, I selectively rephrase answers to model science discourse and incorporate key vocabulary. This scientific rephrasing benefits all students in the class.

DIFFERENTIATING INSTRUCTION

Differentiating instruction[10] means using a variety of instructional strategies that target the diversity of students in the classroom — students with different learning styles, interests, special needs, and those who are also English learners. For English learners, differentiation means tailoring a specific strategy to fit their language levels. It does not mean creating an individualized lesson for each student. It means planning a variety of ways for students to learn new concepts and read new material. It also means controlling speech and using word walls, visuals, and small group learning activities to make input more comprehensible for English learners.

For example, a science teacher who has English learners at two or three language levels (rather than all five) may use the same teaching strategies for all students but differentiate by offering two or three levels of support with a given strategy. In the case of note taking, all students are taught to take notes, and the teacher gives English learners templates with two or three different levels of text already completed, according to their language level. The most novice English learners receive a template that only requires filling in key words and phrases, with pictures for support. Templates for English learners at a higher level present sentence starters and transition words between sentences to help students write connected ideas.

Many of the strategies that help English learners comprehend science texts can also help everyone in the class. Leading students to access their prior knowledge and introducing key vocabulary are standard ways to engage all students in what they are about to read. As an advance organizer that benefits all students, the teacher can also introduce the text's key features and illustrations. In the explain stage, the teacher can read the textbook with the class and "think aloud" about key concepts in the process. Students should also have alternative texts available in a range of readability levels. (Textbook and trade book publishers often produce core science content at various reading levels.) Texts that are brief and interspersed with pictures or illustrations help English learners comprehend while reading. Websites are invaluable for providing alternative texts focused on a given concept or topic, and they often have a high ratio of pictures and graphics to text as well as hyperlinks to key words and related topics.

Other ways the teacher differentiates for English learners include accompanying oral presentations with visuals to help students listen with greater comprehension, giving English learners note-taking outlines or sentence starters to help them capture key concepts in a textbook that they struggle to read, and providing hands-on activities to help English learners "see" and actively engage in learning science concepts and procedures. Presenting the big picture or main idea as a glimpse of what to anticipate prepares English learners to concentrate on what is most important, and then delivering carefully scripted chunks of information allows them time to process it. Connecting instruction to students' experiences and offering choices heighten all students' interest and personalize instruction at a motivational level.

Some students learn better as members of small groups, and small group talk gives English learners a chance for language repetition and practice, so differentiation also means planning for collaborative and cooperative learning activities. The message of differentiation is to be aware of all the ways students are different and to plan ways to teach that capitalize on those differences. Figure 1.5 summarizes a number of ideas in this chapter that apply to differentiating instruction for English learners.

FIGURE 1.5. Lowering the Language Barrier for English Learners

The following classroom techniques have been found effective in lowering the language barrier and differentiating instruction for English learners:

- Tap into prior knowledge to give students richer context for what they will learn. At the same time, activating prior knowledge lets students anticipate vocabulary and terms they are likely to hear and enables them to use context to guess words they do not know.
- Provide wait time after asking a question — it may take English learners extra time to process back and forth in their primary language and English as well as to understand the question itself.
- Have students discuss with a partner or in small groups relevant information from prior science lessons or personal experience; monitor group discussions, and then use a few examples to share with the class. Use flexible grouping in terms of primary languages spoken, English proficiency, general science knowledge, friendships, and other criteria.
- Use multimodal presentations — visuals, word walls, hands-on experiments, etc. — during direct instruction and when summarizing or reviewing.
- Repeat and rephrase important concepts, keeping periods of lecture or reading brief and concise but highly contextualized. Present new words in the context of the lesson and apply words during the lesson, pausing to emphasize each key word.
- Use tiered lessons that address the same standards and topics but that adjust the difficulty level to challenge without frustrating students. For example, plan opportunities to restate a chunk of oral instruction in simpler form for English learners, perhaps while other students do seatwork; provide texts at different reading levels; assign seatwork tasks that differ in language demands; assign learning activities to small groups in which more proficient English speakers rephrase concepts and English learners are assigned less language-demanding parts of the task.

During assessment, the teacher also differentiates. For example, if students are to write about what they have learned, they are not uniformly presented with a blank sheet of paper and the general direction to "Explain the cycle of rock formation." Some English learners will more appropriately be asked to respond orally to a series of guiding questions. Others may be provided with sentence starters or graphic organizers that help them communicate what they have learned. Often, graphic organizers and other strategies implemented during instruction are also appropriate for helping English learners communicate during assessment. Figure 1.6 presents an example of assessment differentiation that accommodates English learners at different levels of proficiency.

FIGURE 1.6. Assessment That Accommodates Different Levels of English Proficiency

In the example below, the teacher provides assessment accommodations at three levels of English proficiency. The goal is to learn as much as possible about what English learner students have or have not understood about science content, not to demonstrate that they are not yet proficient in English.

- Beginning English learners are given a template and asked to visually represent key ideas in pictures, diagrams, or graphic organizers. Students include labels and complete simple sentence starters as appropriate to their level of language development (Igneous rock looks _____. Igneous rock is formed when _____.).
- Intermediate level English learners complete a visual representation and also complete sentence frames that help them connect ideas (Igneous rock looks _____; sedimentary rock looks _____. The difference is a result of their formation: igneous rock is formed by _____; in contrast, sedimentary rock is formed by _____.).
- More advanced English learners use a graphic organizer to help write a composition that follows a model (introductory statement, description of each key point with supporting evidence, and summary, conclusion, inference, or generalization) with or without paragraph starters.

In later chapters, the ideas explored in this chapter about the 5 Es model, modes of instruction, and differentiation will be expanded and elaborated upon with specific tools and scaffolding techniques. In the next two chapters, however, we pause to consider the implications of language acquisition theory for classroom practice, and we explore students' language abilities at five levels of English proficiency.

ENDNOTES FOR CHAPTER 1

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[4] Krueger, A., & Sutton, J. (Eds.). (2001). *Edthoughts: What we know about science teaching and learning* (p. 2). Aurora, CO: Mid-continent Research for Education and Learning.

[5] The definitions of the 5 Es are adapted from *Strategic Science Teaching* (2002), a framework developed by the California Curriculum and Instruction Steering Committee Science Subcommittee and California Department of Education.

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