involves use of tasks that integrate appropriate processes and information to construct meaningful learning experiences for students (Thier 2002). As explained in Chapter 7, a major proponent of this approach, Robert Karplus, even studied with Piaget in order to develop the learning cycle, the driving force of inquiry instruction in science education today (Fuller 2002).

Best Practices in Science Teaching and Language Teaching

There are many different opinions about which teaching methodologies constitute best practices in science teaching or in language teaching. Methodologies in both fields have changed over the years as discussed in Chapter 10. A comparison of current views on best practices suggests parallels between science and language teaching and also how to integrate methodologies of the two.

Science theories on learning influence current pedagogies. The constructivist theories described in the previous sections have broad implications for science teaching practices. One of the most reader-friendly works entailing best practices for a constructivist classroom is *A Case for the Constructivist Classroom*, written by Brooks and Brooks (1993). These authors provide five guiding principles of constructivism using

1. problems of relevance to students in instruction,
2. structured learning around primary concepts,
3. students' points of view,
4. adapted curriculum to address students' suppositions, and
5. assessments of students' learning in the context of teaching.

A second example of science instruction was set forth by Wheatley, who proposed that the teacher's role is to "provide stimulating and motivational experiences through negotiation and act as a guide in the building of personalized schema" (1991, p.14). Wheatley's problem-centered learning approach includes three components: tasks, groups, and sharing. He suggests that, in preparation for a class, teachers should select tasks with a high probability of being problematic for students. Second, the students should work on these tasks in small groups. During this time, the teacher attempts to convey collaborative work as a goal. Finally, the class is convened as a whole for a time of sharing. Wheatley notes that the teacher should then lead the class in a discussion in which each of the groups presents its solution methods, inventions, and insights. This opportunity for sharing promotes higher-level thinking and reasoning skills and often leads the students to further "conversations" and independent thinking.

Another pedagogical approach specifically related to science education is Saunders' four-step approach (1992). The first step is to organize hands-on investigative labs. These are problem centered and differ from the traditional "recipe" labs in that there are no or few prescribed methods or procedures. Students must use their own schema to formulate expectations about what is likely to be observed. The second component is active cognitive involvement. This is in contrast to the passive learning that takes place in many "teacher-centered" classrooms. Saunders explains that learning is made meaningful through activities like "thinking out loud, developing alternative explanations, interpreting data, participating in cognitive conflict (constructive arguing about phenomena under study), development of an alternative hypothesis, the design of further experiments to test alternative hypothesis, and the selection of plausible hypotheses from among completing explanations" (p.140). The third component involves students working in small groups. Saunders says that small-group work tends to stimulate a higher level of cognitive activity among larger numbers of students than does listening to lectures and thus provides expanded opportunities for cognitive restructuring. Fourth, he considers higher-level assessment. Although he does not fully address alternative assessment, the literature on it is vast and suggests that "considerable advances in learning follow when teachers use assessment formatively" (Harlen 2001, p. xi).

In their discussion of language teaching practices, Herrell and Jordan (2004) note that many of the approaches teachers use with all students can be used with English language learners with additional planning. Their premises for effective instruction are that teachers should

- provide instruction that ensures that students are given comprehensible input,
- provide opportunities to increase verbal interaction in classroom activities,
- use teaching strategies and grouping techniques that reduce the anxiety of students, and
- provide activities in the classroom that offer opportunities for active involvement of the students (p. 5).

Jameson has summarized four best practices for teachers of language learners to use in the classroom (1998):

1. Make content more understandable to students by providing nonverbal cues such as pictures, demonstrations, and hands-on learning.
2. Increase interaction by using cooperative learning and project-based learning.
3. Increase thinking/study skills by asking higher-order "thinking" questions such as "What would happen if ..." and having high expectations for all students.
4. Use a student's native language to increase comprehensibility when possible.

In recent years, with the focus on developing language and literacy skills for all children in academic subjects, best practices have focused on the teaching of language through content. Haley and Austin (2004) suggest that interactive learning activities with content and student collaboration in the classroom provide the means for helping students develop more complex academic language skills. Becijos (1997) outlines a number of specially-designed-academic-instruction-in-English (SDAIE) strategies for teachers to use, including

- creating instruction that relates to students' prior knowledge,
- tailoring teacher talk to students' English language proficiency levels,
- allowing students to process material in a variety of formats, and
- using assessment methods that allow students to display learning in a variety of ways.

Echevarria, Vogt, and Short have outlined a number of lesson components using the SIOP Model for content area and language instruction. These are described in Chapter 7 in the context of designing science lessons (2004).

We suggest that the following aspects of teaching relate to both science and language learning and, when applied to the classroom, can provide successful learning opportunities for all children:

1. Research-based learning models: Many science and language strategies stem from a constructivist philosophy. Both science and language are learned progressively, and there are a series of steps that build upon student investigative skills.
2. Cooperative learning: Instruction incorporating learning in pairs and groups allows for interaction between students, which is critical for ELL students. Each child works within a group but has individual accountability to the group.
3. Active cognitive involvement (hands-on—heads-on): Passive instructional models in science and language should be used sparingly. The more senses a student uses in learning, the more effective the learning is. Kinesthetic learning experiences with realia are particularly effective in both science and language.
4. Input from students: Teachers in both science and language need to understand the lived experience of children and adjust planning to accommodate the culture, experience, ability, learning styles, or interests of the child.
5. Student-centered classrooms: Students and student learning should be the focus of the classroom teaching. A teacher cannot be both "the sage on the stage and the guide on the side."
6. Integration of subject matter to convey connections to the experiential world: Children learn best when information is integrated and put into a real-world context. Learning content is not isolated from one subject to another.
7. Interaction, discussion, reflection, and teacher flexibility: The key here is for the teacher to be flexible in both curriculum and pedagogical strategies, to work at a pace that suits the majority of students, and to include discussions and reflection as part of every learning experience.

Although this may not be an exhaustive list, instructional practices that benefit English language learners in the science classroom benefit all students and must be continuously reevaluated as students' proficiency levels and needs change. The science teacher reading through principles and methodologies for teaching language may realize that he or she incorporates many of them in science instruction. Conversely, the language teacher reading through the best practices in science may see how similar they are to language teaching practices. This is the nexus of the book and the recurring theme throughout all of the chapters. None of this information is new. What is new is that the two fields are recognizing the similarities, identifying differences, and coming together to accommodate practices to address the academic needs of a linguistically diverse student population.

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