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Accessible Science

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One of the primary goals of bilingual education is to make curriculum accessible to all students. Offering instruction in the content areas in the language of the children and with consideration of their culture is a desirable means of meeting this goal. Unfortunately, however, in many schools in the United States, linguistically and culturally diverse student populations are

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taught by mainstream, monolingual teachers who are provided with little support to make the best advantage of the opportunities that diverse student populations provide. Second language learners are often provided English as a second language (ESL) instruction and then mainstreamed into all-English classrooms for instruction in the content areas. Mason and Barba (1993) report that second language learners rarely receive science instruction at their appropriate grade level or in their primary instructional language. It is no surprise, then, that these students show a pattern of lower academic achievement than their native-English-speaking classmates, particularly in science. Indeed, recent achievement data from the National Assessment of Educational Progress Report reveal that Hispanic high school students scored 24 points lower than their White peers in reading, 24 points lower in mathematics, and 38 points lower in science (as cited in Lara, 1994). Thus, it appears second language learners do not have access to the science education now recommended at the state and national levels (e.g., American Association for the Advancement of Science, 1990; *Bilingual Education Handbook*, 1990; *Science Framework*, 1990).

The purpose of this article is to provide classroom teachers with a model to use in science education that will increase all students' access to the curriculum by drawing upon the diversity represented in the classroom. We provide a framework of good science education and an instructional planning format with specific strategies for teaching science to students of diverse linguistic and cultural backgrounds.

Good Science Education

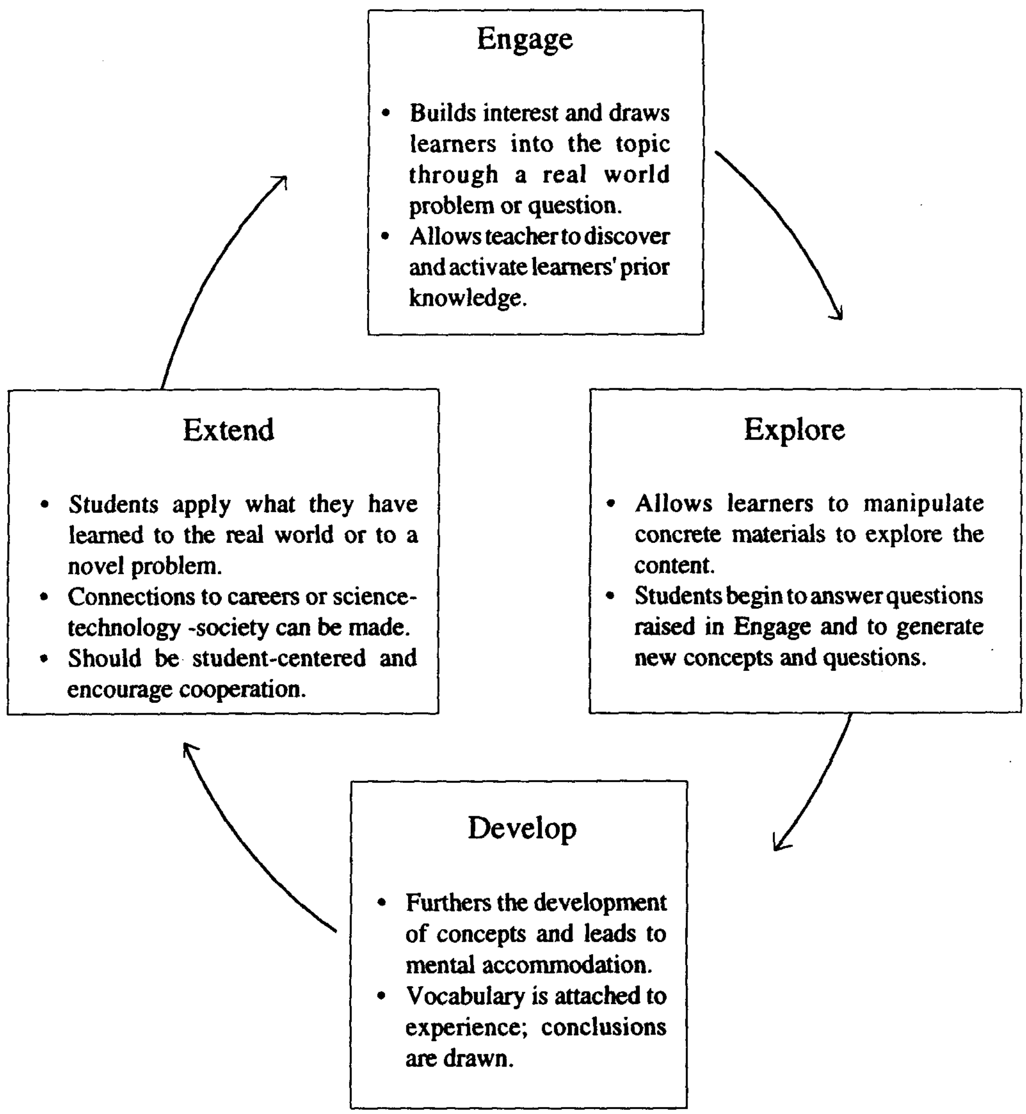
Good science education focuses on three critical elements: growth in *content*, *process*, and *attitude*. Science instruction should encourage the development of *content* that is conceptually oriented and centered on a selective number of big ideas with explanatory power. Additionally, science content development should help students come to see that science is based upon evidence and thus is tentative in nature. Children should also understand that science is fundamentally related to the social, cultural, and historical contexts that surround it. By mastering the *processes* of science—processes like observation, classification, inference, communication, measurement, and experimentation—children should come to understand science as a field characterized by modes of inquiry as a way of understanding the world. Science instruction also must develop appropriate *attitudes* that reflect scientific habits of mind like persistence, skepticism, openness, and curiosity that will fuel future endeavors with the natural world and with personal and social issues. Further, science instruction should encourage positive attitudes toward science so children find beauty in the natural world. Through good science instruction, children should come to see science as an enjoyable endeavor that can lead to a variety of careers and to the enrichment of life (*Bilingual Education Handbook*, 1990). By encouraging the development of content knowledge, process skills, and attitude formation, teachers help bring their students toward the ultimate goal of science education: scientific literacy. Scientifically literate learners can use fundamental theories and principles to find order in the world, can analyze social and personal issues critically, and can act in ways that reflect the effects of science upon humans' lives.

Appropriate Instruction

In his book, *Empowering Minority Students*, Cummins (1989) discusses the value of an "interactive/experiential" (or constructivist) model of teaching and contrasts it with a "transmission" model. In the former model, students are encouraged to be "active generators of their own knowledge" (p. 63); in the latter, the teacher's task is one of imparting knowledge or skills to relatively passive students who absorb the knowledge. Interactive/experiential teaching places the teacher in the role of a guide, one who encourages student-student talk in collaborative learning settings and who consciously integrates language use and development with all curricular content. In short, says Cummins, "pedagogical approaches that empower students encourage them to assume greater control over setting their own learning goals and to collaborate actively with each other in achieving these goals. The instruction is automatically 'culture-fair' in that all students are actively involved in expressing, sharing, and amplifying their experience within the classroom" (p. 64). Building on students' background knowledge and experiences, involving them in activities that help them raise their own questions, and providing many opportunities for them to interact with one another to build shared experiences are fruitful means for creating an environment that supports both language development and knowledge construction.

The constructivist approach that Cummins advocates for all students and subject areas is particularly appropriate for science because good science education needs to help children build coherent understandings of the world through active processes in social settings. Scientific experiences within the context of a constructivist approach can aid in content and language development and cultural understanding by cutting across cultures and allowing for maximum student involvement in the learning process (Sutman, Allen, & Shoemaker, 1986). This is echoed in the recommendations of the national reform of science education, Project 2061 (American Association for the Advancement of Science, 1990), which urges teachers to address the needs and interests of all students with a common core of knowledge and experience, to use instructional approaches that capitalize on the questions and interests of children, and to engage children

Figure 1. The Learning Cycle.



in active learning with hands-on materials and relevant problems. All these needs are met by the learning cycle approach.

The Learning Cycle

The learning cycle strategy, widely and successfully used in science education (Martin, Sexton, Wagner, & Gerlovich, 1994), is an inductive planning and instructional format that provides a structure for teachers to meet the needs of diverse students in providing good science education. First, its cyclic nature begins and ends with interesting, real-life problems that engage the minds of the learners and allow them to connect science to their own lives and to the world around them. Second, it provides opportunities for students to build a common base of experience and to work with data in order to search for patterns, form generalizations, and interact with text; this allows for the use and development of language in purposeful contexts. Third, the components of the learning cycle provide opportunities for peer interaction and cooperative learning which can foster content learning, positive social interaction, and language development (Kagan, 1986). Finally, the learning cycle can be used to recognize the contributions of diverse cultures to our current understanding of science, medicine, and technology.

Although many forms of the learning cycle exist, one helpful form follows the four phases of *Engage, Explore, Develop,* and *Extend.* Figure 1 briefly describes each phase, and the text that follows gives more information and specific examples for teachers wishing to address diverse students' needs through the implementation of the learning cycle in their science instruction.

Engage

The Engage phase draws children into the topic by encouraging their thinking through some real world activity or question; it sparks questions in the minds of the learners. It also allows the teacher to determine which prior conceptions and values children bring with them to the current lesson. Research reveals that a learner's prior knowledge plays a significant role in the construction of new knowledge. Schema theory offers an explanation of research findings that have consistently shown that individuals' background experiences and knowledge are directly related to their ability to understand new, related concepts. Because schemata are constructed through individuals' experiences, an effective teacher promotes knowledge construction in students by providing experiences that encourage students to attain relevant knowledge prior to encountering a new experience.

Examples of activities useful during the Engage phase are the KWL chart, semantic maps, and peer interviews. The Know, Want to Know, Learned (KWL) chart provides a vehicle for the activation of background knowledge on a given subject and for eliciting students' questions about the topic (Ogle, 1986). The KWL chart is intended to be used during the initial phase in the learning cycle as well as in subsequent phases. As a means of engagement, students brainstorm and record all they know about a given concept on a chart in the first column labeled, "What I (or We) Know" (see Figure 2). For instance, if students are going to be studying owls, they generate lists of what they know about the animal. Their contributions may include their first-hand experiences with owls or information gleaned through readings, viewing movies, home life, or conversations with others. Students may work in groups of three to four children to generate a list of what they know about owls, or they may be asked to contribute to a large class chart. Learners may generate inaccurate information in the "What We Know" column.

Figure 2. KWL Chart.

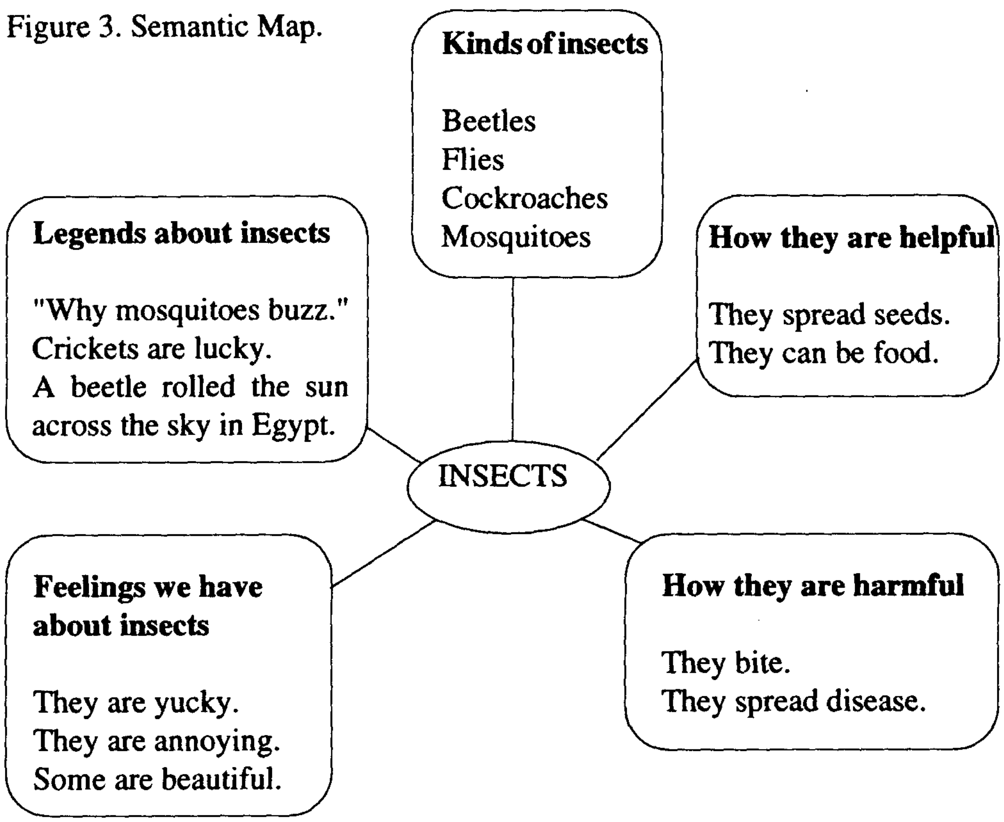
What We Know	What We Want to Know	What We Learned
Owls sleep during the day.	Do their heads really turn all the way around?	
Owls are wise.	Can they pick up large pets and carry them away?	
There are lots of kinds of owls	Do they bring bad luck?	
Owls fly.	What do they eat?	
Owls have sharp claws.		
Owls hunt mice.		

This phase of the KWL chart is followed by the students generating a list of questions that they have about owls: Do their heads really turn all the way around? Can they pick up large pets and carry them away? Students' questions are written in a second column labeled, "What I (We) Want to Know." Thus, the students bring themselves to the experience by drawing on their previous knowledge and by identifying questions they have about the topic. The content, then, becomes personally meaningful, and all students have the opportunity to contribute regardless of language proficiency or previous exposure to the subject matter. All students can profit from this strategy, but it is particularly valuable for second language learners, according to Cooper (1993), because "it immerses them into a natural discussion and offers a strong scaffold provided by teacher support and student interaction" (p. 133).

A second activity that is appropriate during the Engage phase of the learning cycle is semantic mapping. Semantic mapping provides a means for visually organizing related ideas and connecting the known with the new (Farnan, Flood, & Lapp, 1994; Heimlich & Pittelman, 1986). For instance, before students begin the study of insects, the teacher writes the word "Insects" in the center of the chalkboard and solicits students' comments about insects. To support and focus students' thinking, the teacher provides categories for students to consider as they contribute to the map. Categories for this example may include: "Feelings we have about insects," "Kinds of insects," "How they are helpful," "How they are harmful," and "Legends about insects" (see Figure 3). The advantages of this activity are that it draws on prior knowledge (allowing students to bring themselves to the content), develops vocabulary, and meaningfully organizes information. Teachers can help lower the affective filter for second language learners in this oral activity by allowing think time, partner discussions, or cooperative group discussions. Often contributions students make to semantic maps induce disequilibrium in others because some students have misconceptions or more developed knowledge about the content. As students listen to one another and watch the map expand, questions arise and interest is piqued.

A third activity appropriate for the Engage phase of the learning cycle is peer interviews. Kagan (1994) offers several structures for engaging students in peer interviews. One of these is the Value Lines. A statement is posed to students who then rate themselves along a scale of, perhaps, one to five in terms of their level of agreement with the statement, "Snakes are bad." Older children may be asked to rate their agreement with the statement, "Science has dramatically improved the quality of life." Students think about their reactions to the statement, assign themselves a number with one being strong disagreement and five representing strong agreement, and they then line up in order from one to five. After the line is formed, it doubles back on itself, so students stand face to face, with ones facing fives and so on. Students are given the opportunity to interview their partners on their reasons for their position. Partners listen to each other and repeat what they have heard before telling their own opinions. The line may then advance, wrapping around once more, so that children have the opportunity to hear diverse viewpoints. This activity is appropriate for students at the intermediate level of English fluency who feel comfortable with oral expression through peer discussion. It aids language development because it requires partners to listen actively, to paraphrase what they have heard, and to repair possible breaks in communication.

Figure 3. Semantic Map.



More appropriate for students at preproduction or early production levels of language acquisition is a modified version of this strategy in which students are asked to arrange picture cards in some order (e.g., "Arrange these animals in order of those you like the most to those you like the least," or, ". . . from the most useful to the least useful") and then compare their rankings with those of others.

Peer interview strategies allow students to tap their own feelings, knowledge, or experiences regarding a topic, and then to talk with a peer. Background knowledge is activated, communication is enhanced in the one-on-one setting, and students' understandings may be challenged as they hear the perspectives and experiences of others. In order to ascertain students' prior understandings and experiences with the content, the teacher can circulate and take anecdotal notes of the interviews as they occur. These notes will prove useful as the teacher plans future phases of the learning cycle to address students' interests and conceptions of the content.

Explore

The Explore phase of the learning cycle allows children to manipulate concrete materials in order to investigate the topic under study. They begin to answer questions they raised in the Engage phase and to generate concepts and new questions. This phase provides many opportunities for students to use science process skills like observation, measurement, experimentation, inference, and communication. Scientific attitudes, such as curiosity and persistence, also are encouraged in the Explore phase and later. In the Explore phase, students participate in hands-on activities together. They have the opportunity to interact with materials and with one another. Students are full participants in the teaching/learning process rather than spectators as they engage in activities. Language is purposeful and spontaneous.

Activities that children find interesting, surprising, or even mildly distasteful are particularly useful in this phase because they may evoke strong reactions; anxiety about communication is lowered and language is spontaneous. An Explore activity that may follow students' discussions about owls (described in the Engage phase) involves the pairing of students to examine owl pellets. Students are given the pellets to examine; then they are encouraged to separate the fur from the bones and to reconstruct skeletons of animals ingested and then regurgitated by the owl (*Project WILD*, 1992).

Another example of an activity at this phase of the learning cycle is the exploration of a variety of materials that are attracted by magnets. "Does a pencil stick to a magnet? Does an eraser? Do lunch bags? Paper clips?"

In addition to evoking strong responses and spontaneous language from children, these activities encourage the development of scientific attitudes: curiosity, persistence, skepticism. They prompt children to ask their own questions, which is key to the pursuit of science and to the integration of content and language.

The activities that students participate in during the Engage and Explore phases of the learning cycle provide a shared base of experience among class members. Language is in a natural context that allows for different levels and kinds of peer-peer communication so new speakers of a language and more experienced ones can succeed in a lower-risk setting. At the same time, the teacher circulates among the students to draw out children's language and to build upon it.

Develop

In the Develop phase, the teacher assists students in developing concepts and understandings that they were beginning to construct in the previous phase. Vocabulary is attached to experiences, conclusions are reached, and knowledge is systematized. It is in this phase—after students have activated prior knowledge and had experiences with concrete materials—that reading text becomes meaningful. Thus, during the Develop phase, teacher and students together generate explanations for the phenomena under study. Two strategies that are appropriate during this phase are KWL and journal writing. Both strategies encourage children to organize their thoughts and to use language to convey and extend understanding.

The KWL strategy, described earlier as an Engage activity, is an excellent strategy for prompting children to think about and record what they have learned. After identifying what they already know about a topic, listing what they want to find out, and having a hands-on experience, the children write in the "What We Learned" column of the class KWL chart what they have learned and modify any earlier misconceptions. Students think about their explorations, use language to explain what they have learned, and listen to the comments of their peers, all in the meaningful context of their experiences.

With the experiences and discussions serving as a foundation to their understanding of a concept, children now may be guided through a reading selection about the topic. The knowledge they activated in the Engage phase and the experiences they had in the Explore phase allow them to more fully comprehend the selection. Because they have thought about the topic and already have used language to express their knowledge about the topic, they are ready to understand what they read. The reading selection may be a single text that the entire class reads, or students may read about the topic from a variety of texts, including a science text, informational books, encyclopedias, or resources the teacher has available. Teachers may wish to capitalize on technological resources; CD-ROM materials, for instance, frequently present visual and auditory cues simultaneously and are often available in multiple languages. (See Sutman, Allen, Shoemaker (1986), for additional suggestions for preparing second language learners to read science materials.) After reading, students return to the "What We Learned" column to record further insights and understandings.

Journal writing also provides students with the opportunity to think about their experiences and to develop their vocabularies through the use of the formal language of science, thus promoting a deeper understanding of concepts under study. Several journal formats are appropriate for recording science experiences. In one format, the reading log, the teacher provides questions in order to guide students' thinking about the text, a passage, or an experience, and to help them make generalizations or draw conclusions. For example, the teacher might ask students to record their observations: "What happened when we turned off the switch?" "What did you notice about the clam shell?" "Draw what you saw when you looked through the microscope and use words to describe it." Or, the teacher might ask students to offer explanations of phenomena: "Explain why the soil erodes more in the box that has no plants growing in it."

A second kind of journal is the learning log. At the end of a class period, students jot down in their learning logs any thoughts they have about what they learned, what they did not understand or were unsure of, and something else they would like to know about what they studied. This kind of log "leads students to put ideas together in new ways" (Langer, 1991, p. 19) because students are encouraged to think about and question the new learning. The teacher reads the logs and responds to the students in any one of a number of ways, such as individual written responses, individual conferences, and class discussions.

Double-entry journals allow the students to record observations or experiences in one column, and to respond to them in a second column. The students can fold a piece of notebook paper in half lengthwise. In one column, they record something they learned or experienced. This can be something that happened during the Explore phase of the lesson, or it can be something they read or discussed during the Develop phase. Directly across from this information, in the second column, the students react to what they wrote. For example, a student might write in the "Information" column that a squid moves by spitting water out of its siphon. In the "Response" column, the student might note that that is what happens with an inflated but untied balloon if you let it go.

Although journal writing is typically an independent activity, students can work with partners or in small groups to describe a phenomenon or to develop a generalization. What they compose together can be transferred into individual journals. This peer support is especially important for second language learners.

Journals provide excellent opportunities for students to build new knowledge and to use the language of science. Barba (1995) states that journals prompt students to assume ownership over new knowledge and to construct labels for what they have just learned. Further, writing requires analysis and presentation of data in an organized manner. Journals also provide teachers with insight into the ways students have constructed knowledge. (See Yopp & Yopp, 1992, 1996, for a discussion of several different journal types along with multiple examples.)

Extend

The Extend phase completes the cycle by allowing students to apply their new knowledge to other contexts or to other related issues or problems that surface in the real world. Because learning is carried beyond the bounds of the classroom, the Extend phase helps learners to see that their knowledge connects to other contexts. This phase can be used to provide a final evaluation of learning through performance-based means or hypothetical reasoning.

The Extend phase serves a number of general purposes. It can be used to encourage students to solve related problems within science or to use the new concept in a different setting, which is important because multiple representations of the concept or learning can help ensure that students develop full understanding of the critical attributes of the phenomenon. This phase can also be used to explore science-technology-society connections so students see new information gained through science instruction as related to technological and societal issues. It can allow students to find interrelations among the science concepts at hand and ideas from other subject areas. Finally, the Extend phase can be used to explore careers related to the content under study.

In addition to these general purposes, the Extend phase can also serve to meet the needs of culturally and linguistically diverse groups. First, the Extend phase can provide an opportunity to build home-school connections by including parents (or other family members) in the students' growing scientific literacy. For instance, after studying insects at school, students may extend their learning by interviewing a grandparent about the role of insects as food sources, as agents of plant reproduction, or as nuisances within the home culture either now or long ago. Oral or written traditions also may show the role of the content within the home culture. In the example of insects, for instance, many cultures' folktales and songs include insects as significant characters.

Second, the Extend phase can be used to support school-community connections by relating school learning to the community and using it where appropriate in ways that benefit the local community. In this way, the Extend phase can serve as a vehicle for social action that empowers children to use knowledge in shaping their community. Lewis (1991), for instance, provides powerful examples of children effectively tackling local problems like a hazardous waste site, and she provides useful strategies for helping children select and solve social problems. Some sample strategies include interviews, letter writing campaigns, speeches, surveys, petitions, and fundraising. Conversely, life in the community may serve as a powerful source for suggesting relevant content for future learning cycles.

Third, if the contributions of diverse groups were not explored in earlier phases, the Extend phase can be used to acknowledge and examine the contributions of diverse groups to discoveries related to the content at hand. Students studying astronomy would benefit by learning that Native Americans (the Anasazi) used their knowledge of astronomy to position their dwellings to make maximum use of the sun's energy, or that long ago Muslim scientists constructed sophisticated astrolabes in order to chart the movement of the stars (Selin, 1993a; 1993b). In studying geology and the forces that shape the earth, children can learn that Chang Heng, the royal astronomer of China, invented a device to detect earthquakes in the year 132 A.D., nearly 700 years before the first Western seismograph (Selin, 1993b). Examples such as these can help children learn that every culture has been involved in observing and controlling the environment so that people from all over the world have contributed to what we know today.

Fourth, based upon children's learning preferences, the Extend phase can allow learners to display their knowledge in ways they themselves select. Providing a variety of response strategies can not only address different learning styles, it can also help to ameliorate difficulties that may result if students acquiring English are expected to communicate their knowledge only through written language. For instance, learners may display their understandings through drawings, enactments, or models—all of which allow for students to respond to content in meaningful ways and in ways that are respectful of the fact that children are simultaneously acquiring language **and** content knowledge. Works such as Tolley's (1993) guidebook for integrating science and art and Tippins and Dana's (1993) article on culturally relevant alternative assessment suggest strategies for teachers who wish to expand the range of opportunities they present to students to convey their knowledge and commitments.

Finally, the content can be explored in terms of its cultural import during the

Extend phase. Because science is a social enterprise, the issues that become labeled as significant or as problems for solution are highly culturally constrained. The meaning attached to natural phenomena by humans provides a fertile exploration ground of cultural values and their relations to scientific study. For instance, because the ancient Chinese were not constrained, as were Europeans, by a God who would allow for no irregularities in the heavens, they were able to see comets long before Western scientists did.

Thus, the final phase of the learning cycle can encourage not only the application of new science learnings, but through their ties to the wider world, should serve as the basis for future learning cycles that help children to see science as a relevant, human enterprise.

Putting it all Together: A Sample Learning Cycle

Picture a culturally diverse group of sixth-graders with a range of English language proficiency about to have their first lesson on current electricity. Their teacher is interested in developing two concepts for the day: the necessary components of a complete circuit and the idea that some materials conduct electricity and others do not.

In the Engage phase, Ms. G.'s motive is to hook the students with an intriguing problem and to discover what they already know about electricity, particularly because many students bring misconceptions about electricity to the science classroom. Ms. G. displays a toy chick that chirps when she holds it in her palm. (The children do not know that the chick has two metal pads on its feet that, when touched simultaneously by certain materials, allow for the completion of a circuit.) She challenges the children, "Please ask me yes/no questions to determine what makes my chick chirp." She models examples of this question format for her students. When individuals' questions become sparse, Ms. G. asks students to discuss their thinking in their cooperative groups and then phrase a group question. Thus, children at early levels of speech production have the support of more fluent peers to phrase questions. Many notable lines of thought emerge. One group asks, "Does it chirp because there is energy in *you*?" They pursue their reasoning by having Ms. G. test the chick on the (metal) arm of the overhead projector. The chick chirps! To explain that the overhead projector allows the chick to chirp even though the projector is not alive, students in another group protest because the overhead is plugged in: It is receiving energy from the wall socket. Groups around the room shout, "Unplug it!" Still the chick chirps.

Although many students have concluded that certain materials allow electricity to flow through the chick, Ms. G. does not worry about reaching a single conclusion at this point. What is important is that the Engage phase has allowed Ms. G. to explore the children's reasoning and has induced a bit of disequilibrium for students as they challenge their own notions about electricity. Further, she has allowed students to think about electricity with an example relevant to their lives: a toy.

Ms. G. encourages students to Explore current electricity by passing out foil, masking tape, strings of small Christmas lights cut into sections, and D-cell batteries. She uses some questions to encourage students to investigate the properties of a complete circuit: "How many ways can you make the bulb light? How many bulbs can you light with one battery? Can you use something other than the wire? What else can you try with these materials?" As the children work in their groups, Ms. G. circulates, listening to the language children are using ("Put it on the bumpy end of the battery!"), watches to see what concepts children are pursuing (One groups suggests, "Let's use all of our batteries together."), and makes mental notes for future lessons. She also invites students to examine the work of other groups in order to fuel their thinking. When groups fail to use foil and masking tape, Ms. G. suggests it, knowing they will want to use the properties of those materials later.

After students have had plenty of time to explore, Ms. G. guides them into the Develop phase. First, Ms. G. reviews a few of the phrases she heard children use and supplies a term to represent those informal phrases. "I noticed you saying 'the bumpy end of the battery.' Point to that end now. We call that the *positive terminal*. Try repeating it after me if you like: positive terminal. I'll write it on the board in case you need it later." By supplying vocabulary after students have had concrete experiences, Ms. G. hopes to encourage richer and more useful mental representations of the terms than would be allowed if she started the lesson with a "copy the definitions" exercise.

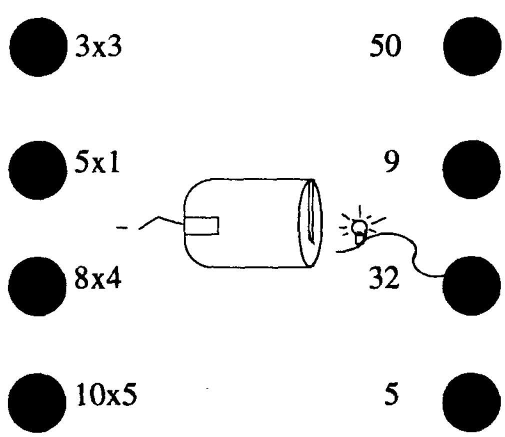
Students' lab sheets have several simple diagrams of a bulb connected to a battery in various ways. Students set their materials aside and work alone using what they have just discovered to indicate whether the bulb in each diagram will light: yes or no. This gives the students the opportunity to test their developing knowledge about the necessary components of a complete circuit. By using unison response, Ms. G. determines that students are forming correct notions about circuitry and asks the students to formalize their thinking: "In your groups, now, compose one sentence that tells what a complete circuit is." Groups work for 10 minutes, then post their sentences on sentence strips at the front of the room. As the class reads each, the students decide whether the sentences—

although worded differently—precisely communicate the necessary components of a complete circuit.

To develop the concept of some materials conducting electricity and others that do not, students during the Explore phase tested materials around the room to determine whether the materials would allow the bulb to light: "Let's try Rogelio's braces! Try my necklace. Does the desk work?" Because they recorded materials on a chart [Yes (Conductors) or No (Insulators)], it is easy for students during the Develop phase to reach a tentative generalization about materials that conduct in the classroom setting: Metals are the best.

Satisfied that the students are developing appropriate notions about complete circuits and conductors and insulators, Ms. G. moves the class to the Extend phase. She provides and models a task that asks students to use what they discovered today: "Take a look at my circuit board here. It's like a game. If I touch this end of the wire to the picture of the bird and this end to the picture of the nest, the bulb lights up. Notice, though, that if I touch this end to the picture of the bird and this end to the picture of the aquarium, the bulb does not light up. Your job now is to make your own circuit board so that only the correct pairing will make the bulb light. Choose your own topic and items to match. You'll need to use what you know about complete circuits, conductors, and insulators. Work with your partner right now to understand the problem and devise a plan. I'll check back with you in a few minutes." As they talk, Ms. G. passes out manila file folders with holes punched in two columns. She also reminds the students about available materials: foil, paper, and masking tape.

Figure 4. Sample Circuit Board.



Applying their newly constructed knowledge presents a challenge for the students, and they spend the rest of the morning building circuit boards that meet the criteria. (See Figure 4 for an example.) Children who finish early ask to make another. Many students check out batteries and bulbs, and because these materials are inexpensive, Ms. G. provides folders and foil for the students to take home so they can impress or stump their parents. Children are encouraged to bring toys or other objects from home that are battery powered to show to the class over the next few days. Future lessons will focus on building more sophisticated notions of circuits and upon the social and environmental issues related to electrical energy use around the world,.but that's enough for today.

Conclusion

The learning cycle offers a planning format for science instruction that: (a) provides access to the content and to process and attitude formation, (b) supports second language learners' language development, (c) values diverse backgrounds, (d) promotes peer-peer interactions, (e) allows for exploration of multiple contributions to scientific knowledge, and (f) suggests multiple representations of student learning. Diversity in the classroom can serve to enrich the learning that occurs through participation in activities in each phase of the cycle. Diversity is an asset as students learn about the background experiences of one another, engage in hands-on exploration in a social setting, develop their understanding of content, enlarge their vocabularies, and extend their knowledge as they consider the relevance of their learning to their own lives and to the larger communities—past, present, and future. Through this model, scientific literacy is an accessible goal for students of all linguistic and cultural backgrounds.

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