Family Gardens and Solar Ovens: Making Science Education Accessible to Culturally and Linguistically Diverse Students

By Barbara J. Merino & Lorie Hammond

Snapshots

Eight Mien children cluster around the table with a Mien parent, examining seeds which they are about to plant. The parent, who has collected the seeds from his garden, asks the students to identify them. Discussion ensues in Mien. Finally, the parent helps the students to plant the seeds in containers, in preparation for transplanting to the school garden at a later date. At another table, students study the parts of plants with their classroom teacher, thus building their English and science skills. A little later, in the same room, a Russian parent who was an artist in her own country leads students in a lesson on drawing vegetables. Although only one child in the class speaks Russian, the lesson is so visual that everyone can understand. The Russian parent finds that by helping in the classroom, she is learning English.

At another school, where children participate in a Spanish immersion program, a classroom is working with parents to plant and identify traditional Mexican herbs. After discovering that herbal lore is a body of knowledge which parents from this community would like to preserve, the school has decided to reserve a part of its garden for displaying and labeling these plants. Literacy projects involve making books about the herbs and their uses, using parents and grandparents as informants. One parent has written several songs about herbs, which children now sing in Spanish.

These two snapshots describe classrooms using the Bilingual Integrated Curriculum Project (BICOMP). Although each focuses on lessons adapted to a specific language minority community, they share common elements that make them effective multicultural education. In both cases, the science curriculum is built around activities that minority communities are familiar with and value. Teachers can use these elements to teach English and grade-level concepts, using a constructivist approach, while parents share traditional knowledge and primary language skills. We believe that this approach makes current science education reforms accessible to language minority students.

The Big Picture

Science and minority students: The performance of minority students in science and reading achievement tests as reported in national studies lags behind that of majority peers, with the exception of some Asian students. However, as recent educational reforms are applied to the schools, a reversal of some of these trends is becoming a reality. For example, both Hispanic and African-American students showed improvement in their performance in science in 1989 (College Entrance Examination Board), perhaps reflecting the science education reforms of the 1980s. However, both groups were still overrepresented in the lowest quartile and underrepresented in the upper quartile of the population.

While science reforms, such as hands-on activities and a constructivist approach, can merge with methodologies that promote success in multicultural populations, this is not automatically the case. For example, some constructivist activities in math and science are so linguistically demanding that, unless they are redesigned, they exclude English learners even more than would more traditional, computational activities.

In this article, we will discuss the ways in which research on culture and language can be merged with national science reform efforts to create success for minority students. After familiarizing the reader with some of the general reform efforts in science education, we will describe how BICOMP has blended multicultural educational practices with science reform to create an exemplary program for minority students.

Current trends in science education reform: Fensham (1992), in his analysis of research on curriculum in science and technology, outlines several major trends in science education. Here we highlight those that relate to the issue of culture and language.

First, there has been a radical shift in thinking about who should be competent in science, not only in the United States, but in most other countries as well. In the past, science achievement was expected only from an elite who had made it to advanced secondary education and who might choose careers as scientists. By the beginning of the 1980s, 70 percent of the students in most industrialized countries completed secondary education. Greater numbers and more socially representative cohorts have challenged teachers to provide curricula and instruction that work in a wide variety of settings with ethnically and linguistically diverse students.

Second, it should be noted that most of the work to adapt science educational practices to ensure greater equity has focused on girls. Fensham outlines approaches that have been used to address this issue. First, gender bias in textbooks has been analyzed and attempts have been made to develop more equitable materials. Second, an attempt has been made to offer girls greater participation in science courses and in science classrooms by requiring more science courses, by monitoring girls' participation in classroom discourse, by isolating girls from boys for some course work, and by changing the content of science learning, making the focus more related to societal issues and "nurturative" aspects of scientific principles. (Chemistry from Issues, Harding & Donaldson, 1986, is an example of such curricula.) Last, some (Manthorpe, 1982) have called for a more radical restructuring of the science curriculum by creating a community of coop-
erative learners and by giving respect for different forms of knowledge—including the irrational and the subjective. Many of the reforms that make science more accessible to girls are applicable to other underserved populations.

A third major trend in science education has been an increased application of the constructivist view of learning. This approach, based on Piaget’s developmental research, rests on the assumption that learners are constructors of their own knowledge and that no one else can do it. The teacher’s role is to bring out previous knowledge, to challenge misperceptions through exposure to activities that can test students’ hypotheses, and to guide the learner in the process. The learner’s views are to be respected and can become the topic of inquiry (Osborne & Freyberg, 1985; Fensham, 1989).

Heightened awareness of learners and how their underlying conceptual change may be particularly effective in working with students from diverse backgrounds. Teachers using a constructivist approach cannot assume the starting point for inquiry. If teachers understand that they must dialogue with the body of information which students bring to the situation before beginning their instruction, this dialogue can give voice to cultural as well as developmental variation.

Science and second language learners: Science students who are not native speakers of English face linguistic and cultural barriers to acquiring science in regular classes. The debate over whether to teach these subjects in English or in the students’ native language (Pefhie1, 1988; Ovando, 1989) has shifted to a discussion of the ways in which science instruction can be a vehicle for language development (Spanos, 1989) and for learning the kind of mental thinking and problem solving that scientists use (Tharp & Gallimore, 1989).

A lively debate has ensued, particularly among teachers who work in culturally and linguistically diverse settings, about the efficacy of a constructivist approach in these settings. Teacher concerns include the following: (1) that the focus on inquiry may not be congruent with socialization patterns in students’ homes; (2) that the linguistic demands on students as they talk about their prior knowledge and as they are asked to discuss what they have learned about an activity may be too much for English learners; (3) that students have too little experience with Westernized ways of working in science to generate the topic and structure of inquiry; and (4) that conceptual change may be more difficult for cultural groups in which religious beliefs conflict with scientific explanations of natural phenomena.

A Scenario for Implementing Constructivist Teaching in a Culturally and Linguistically Diverse Setting.

In the early 1980s, a group of faculty at the University of California at Davis collaborated with teachers in several surrounding school districts to develop an approach to teaching elementary science to culturally and linguistically diverse students (Coughran, Hookins & Merino, 1986; Merino & Coughran, 1992). The approach seeks to integrate science with other areas of the curriculum by focusing on broad themes, such as “weather,” in science as well as in art, literature, and math. A topic, such as “rain,” is explored simultaneously through lessons in science and in other disciplines.

BICOMP uses a communicative approach that allows students to reflect on their understanding of a science concept, participate in hands-on activities to explore the concept, reflect on their acquired knowledge, and follow up with an inquiry activity shaped by their own interests. We call this approach “sheltered constructivism.” The approach is called “sheltered” because students first participate in activities under the guidance of the teacher who contextualizes tasks by using communicative techniques and the first language. Students then spin off to further activities that build on questions they want to pursue. Spin-off activities in literature and art integrate resources from a variety of cultural groups.

For example, students learn about wind and rain through science activities in which they actively participate. They may read and re-enact an Indian myth or a Russian fable related to concepts covered in the science lesson. In art, they may look at the work of artists from various cultural groups to analyze how these artists represent weather phenomena, then create their own art work using cold and warm colors.

Several aspects of multicultural education are forwarded by this approach. By integrating art and literature, students are provided with more avenues to make meaning from science themes than through science activities alone. This increases the chance that they will consider science themes relevant to their lives. In addition, by broadening the topic of study to include multiple modalities, various cultural perspectives can be incorporated. For example, if a student suggests that thunder is caused by rain gods, this perspective can be corrected in science class, but might be incorporated as a story in literature. We believe that academic disciplines provide various lenses through which a specific topic can be viewed. One useful lens is Western science, but it is not the only lens.

To more clearly illustrate how BICOMP’s approach works, a cycle from the third grade weather curriculum can be partially described here. In week nine, for example, students explore uses of weather science class. They consider insulation as absorption in the design of a mini model solar oven, exploring how color (black versus white) and type of paper may affect insulation and absorption.

On one occasion, students were orgnized in groups of mixed language ability. In these groups, they designed solar ovens following a set of specifications, using a plastic cup and several kinds of paper. After the activity, they discussed what they learned and what they still would like to explore again, in groups, they developed ovens of their own, using cardboard boxes and whatever other materials they wished to use. Some teams generated very large models, elaborating canopies made of aluminum foil to reflect the sun’s rays. Others opted for smaller models, with complex insulating materials to better preserve the heat. The ovens were then tested outside under standardized conditions, and results were compared and discussed. Students focused on what elements were common to the most successful models and discussed how the ideas had changed as a result of their experiences.

Spin-off activities which carry the concept of insulation into other subject areas include a math, literature, and art lesson involving quilts. Quilts relate to math them in geometry, such as symmetry. In addition, quilting is an activity in many different cultures (Hmong, American, Chinese, Lat American, etc.). Students read The Keeps Quilt, a story in which an immigrant family brings a quilt from the “old country” as passes on to the next generation to generate. This creates a natural milieu in which parents and grandparents can be brought in to display quilts or even teach quilting and embroidery techniques. Student groups design their own paper quilts, as an integrated art and math activity. In some classes, the group quilts are joined together for one large class quilt.

Recently, BICOMP has expanded to include more community input in curriculum development in a manner that builds on Freire’s concept of “funds of knowledge” (Freire, 1970). BICOMP curricula have always focused on science topics such as weather and plants, which are familiar to minority families, so that parents can dialogue with their children about what they are studying. By expanding its study of plants to the creation of family-community gardens project now enables limited speaking parents from both Southern Asian and Mexican communities to participate as teachers of gardening.
Techniques for using the first language

1. Written and oral group reports are prepared in English and in the first language of the students. One teacher groups children by language so that they can summarize the results of their findings in English and in the language of the group. This teacher notes that after holding their preliminary discussions in their first languages, students display more advanced thinking when sharing results with the class than when they work only in English.

2. Students can be grouped heterogeneously by language so that fluent and limited English speakers can help each other, or homogeneously by language so that more fluent English speakers from one language group can serve as translators for their peers.

3. Students may share results and ask questions through a peer interpreter.

4. Parents of young children can collaborate with their children by doing science at home, when simple assignments are provided in their first language and involve home activities.

5. Instructional aides can preview/review key concepts and activities in Language One.

Techniques for contextualizing input

1. Reports are contextualized by asking students to demonstrate models of their solar ovens, or of whatever materials are used, to show as results are discussed.

2. Teacher instructions are tied to "realia" (the objects, materials or instruments the labels refer to). Key concepts are always explained in several modalities in addition to speech. Visuals, dance, drama, music, and real objects are used as appropriate.

3. When a child asks a key question or makes a key comment, the teacher connects it to a context, by pointing to the materials referred to.

Techniques for infusing culture

1. Priority is given to curriculum themes that are familiar to children and their families, such as "weather," "plants," and "gardens" in a farm community, so that students and parents can contribute more readily.

2. Art and literature spin-off lessons are infused with materials derived from community cultures, such as local folk tales, herbal lore, holidays, or crafts.

3. Language aides and parents are used as informants to expand ideas in the curriculum. For example, Southeast Asian parents, assisted by interpreters, can inform the class about their experiences with rain forest plants or their knowledge of gardening.

4. Classroom atmosphere and teaching style are culturally sensitive and create a warm, open atmosphere for cultural sharing.

model expert gardening practices in their native languages, while teachers use the garden as a resource for science explorations and English language development.

In a community-based homework project, students serve as mini-ethnographers, tapping parents’ knowledge about plants and other subjects, then using this knowledge as data in both science and social studies. Parents who previously did not participate in homework because it was in English and was based on material unfamiliar to them re- emerge as their children’s teachers by instructing their children in family areas of expertise in their primary languages. Their knowledge is then recorded and becomes part of the school curriculum.

\[ \text{Assessing students' progress: BICOMP} \]

In a constructivist approach, both teachers and students are encouraged to be active problem solvers, building strategies, experimenting with them, and redesigning what they are doing. It is essential that teachers have opportunities to dialogue so that new challenges and solutions can be shared. We believe that an essential element of the BICOMP project’s success has been the agency gained by students, teachers, and sometimes parents, who see themselves as problem solvers and inventors involved in a never-ending spiral of learning.

- Barbara J. Merino is a professor in the Division of Education at the University of California at Davis and Lorie Hammond is an assistant professor in the Department of Teacher Education at California State University, Sacramento.

References


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repeated types of assignments over time, so that students’ growth can be charted. For example, if a certain lab report sheet is collected at different intervals, teachers can see students’ progress both in understanding and communicating what happens in an experiment, and in expressing themselves in English. Rubrics are designed to measure student progress.

Implications for teachers’ practice: In the “sheltered constructivist” approach, the challenge for the teacher is to enable all students to understand and engage in discussions regardless of their linguistic abilities in English. Observations in several classrooms implementing BICOMP yielded a list of strategies which were successful in engaging language minority students (see chart, “Techniques for using the first language”).

Conclusion

The “sheltered constructivist” approach used in the BICOMP program has been tested through studies comparing students before and after treatment. Two replications were conducted at two different school districts and significant gains were found in several areas of achievement: reading comprehension, science, and mathematics.

Nonetheless, teachers implementing this approach must continue to monitor how it affects the students they teach. Targeting a few anchor children with different levels of proficiency is one way that the monitoring can be done by an individual teacher. Portfolio reviews and periodic short interviews as well as strategic questioning during group discussions are some of the strategies that can be used by teachers to measure student understanding.

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