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Improving the Science and Mathematic Achievement of Mexican American Students Through Culturally Relevant Science. ERIC Digest.

TEXT: The underrepresentation of minorities in science, mathematics, and engineering has been well documented. Suggested interventions frequently mention better preparation in mathematics and science at the elementary and secondary school levels and increasing the number of intervention programs. The success of intervention programs is well established, but what needs examining are the strategies a classroom teacher can use to help Mexican American students excel in mathematics and science. This digest will explore the use of a culturally relevant curriculum as one strategy.

WHY IS A CULTURALLY RELEVANT CURRICULUM NEEDED?

Culturally relevant science employs materials based on the culture and history of the minority or ethnic group to illustrate scientific principles and the methodology of science already in the school's science curriculum. Our schools assume that Hispanic and American Indian cultures are either anti-scientific or, at best, a-scientific. Concurrently, schools reflect a common belief that the Western cultural heritage is particularly propitious to scientific development. Most of the material available on the development of science as well as the science curriculum taught in school reflects this ethnocentric orientation. The scientific contributions of China, India, and the Islamic nations are usually minimized, and traditional native cultures are frequently depicted as permeated with superstition and magic rather than oriented toward science. Both the failure of Mexican American and American Indian children to take math and science and the small number of minority scientists can then be blamed on deficiencies in their native cultures, thus exculpating the schools and the larger society from any responsibility.

The factors usually examined thus do not include failure of the schools to provide a culturally relevant curriculum. A small body of literature does, however, focus on the importance of teaching culturally relevant science (or ethnoscience) and provides specific examples of a culturally relevant curriculum.

To encourage Mexican American and American Indian children to develop an interest in science and to consider it as a career, a wider variety of examples from different cultures should be used in teaching science. This practice will send a message to the minority child that "my ancestors or people like me did engage in scientific endeavors, and thus I can do it too." The child can take pride in his or her culture's contribution to science and feel a greater degree of individual interest in science.

IS CULTURALLY RELEVANT MATERIAL CONSIDERED SCIENCE?

We should not be trapped by an excessively restrictive definition of what constitutes science, for the definition one chooses will determine what is and what is not considered science. Malinowski (l954), for example, proposed conceiving of science as "a body of rules and conceptions, based on experience and derived from it by logical inference, embodied in material achievements and in a fixed form of tradition and carried on by some sort of social organization" (p. 54). He found that many principles of native knowledge were scientific by this definition. Therefore, using culturally relevant material can enhance the scope of science taught.

WHAT CULTURALLY RELEVANT RESOURCE MATERIALS ARE AVAILABLE TO TEACHERS?

The following are examples of culturally relevant materials developed from a rich, but essentially untapped resource. These examples have been used successfully in the classroom from the primary grades through college.

--Archeoastronomy. Archeoastronomy has provided new information about how ancient civilizations perceived the heavens. Selected sites in the United States (the mounds of the Midwest, the medicine wheels of the Plains States, and Fajada Butte in Chaco Canyon, New Mexico) and in Mesoamerica (Teotihuacan, the Caracol at Chichen Itza, and Building J at Monte Alban) can be used for teaching astronomy, observational skills, scientific methodology, and basic mathematics. Astronomy is especially adaptable to primary school science.

--Maya mathematics and calendar. The most sophisticated examples of Mayan thought are exemplified by their calendar and the mathematics which preceded it. Many years of astronomical observation and meticulous recordkeeping were necessary to achieve the accuracy which they attained. The structure of the calendar was determined by both their cosmological beliefs and by the nature of the mathematical system itself. Because of its complexity, the use of the calendar in the lower grades is limited.

Teaching the Mayan mathematical system is especially appropriate for the primary grades. Mayan mathematics were vigesimal, i.e., with powers of base 20 rather than base 10 as in the decimal system. They also employed place value notation and were one of only two cultures to independently discover the use of zero. The Mayan system uses only three symbols to represent numbers, a (.) for one unit, a (-) for five units and a ( ) for zero.

Several articles have appeared on the use of the Mayan system for arithmetic calculations. George Sanchez, the pioneer in this area, taught this system to school children in Austin, Texas and claimed that, with a small amount of instruction, they could perform arithmetic operations faster in Mayan than in the decimal system, particularly if they used an abacus arrangement. Mayan arithmetic can be used to get children to deal comfortably with numbers in different systems, to have them play with numbers, and in general to demonstrate that mathematics can be fun.

--Geology. Volcanic activity has always been a fact of life in Mesoamerica. This interesting phenomenon may be used to teach basic concepts in geology while studying culture and geography. The trade items of the Mesoamericans were of volcanic origin and/or of plate margin activity (obsidian, basalt, serpentine, and jade). The cenotes (sinkholes in limestone) can be used as a starting point for the study of the geological phenomenon of underground rivers and the composition of land in Yucatan. Geology is particularly well suited for interdisciplinary study.

--Feeding the world: Productivity of food plants. Agriculture, botany-ethnobotany, and nutrition come together to provide the basis for looking at a world problem--hunger. There is no better way to get students interested than starting out with a social issue.

The different uses for and sources of many plants can be discussed with particular attention to the ways in which the Indian civilizations have contributed to food resources. Many of the practices used today in agriculture have their basis in Indian practices; in fact, we may be returning to a modified version of them today. The Aztecs developed chinampas (built up platforms on shallow lakes which were drought-proof and could produce several crops a year). Many of their foods show promise for relieving protein shortages and assisting in reducing the energy cost of agriculture. These new (for us) and unusual food plants can be used as a starting point to discuss the productivity and photosynthetic activity of food plants, their nutritional value, the food production policies of different countries, and what is being done about world hunger.

--Herbal medicine/ethnobotany. The chemistry and uses of herbal medicines can be used to teach students research strategies which involve literature searches, written reports, personal videotape interviews of friends and relatives, and the design of questionnaires to elicit appropriate information. At the higher grade levels, laboratory research techniques can be taught, such as chromatography of plant extracts showing students how chemical components of complicated mixtures can be isolated. These valuable research methods will be needed by the students in their future scientific studies or in their work in other disciplines. At the same time, students will be learning about the development of cultural medicine and its relevance to their own lives.

In teaching classification, ethnobotanical classifications should also be presented. These classifications are logical, and their nomenclature is descriptive of the plant rather than a reflection of the name of the discoverer, as is too often the case in Linnean classification. One can point out that a classification scheme is used because a group of people agree to use it as a standard. The Linnean system is European folk biology elevated by agreement to a science and perfected over the past 200 years. Students can be encouraged to develop their own taxonomic system in order to teach them the logic of the process involved.

The one area that has received some attention in the school curriculum is ethnic foods, but in many cases it has not been used to transmit nutritional information. Information is available from the Cooperative Extension Service in all land grant institutions, since it is used in their Expanded Food and Nutrition Program in all states, or from the Extension Service, U.S. Department of Agriculture, Washington, D.C.

HOW CAN ART BE USED TO TEACH SCIENCE?

There are a number of ways to use art to teach science. Two areas have been well developed. The "Chemistry of Color" is still in the developmental stages.

--Science and creativity in the Diego Rivera murals in Detroit. In the Detroit murals, Rivera placed a special emphasis on the positive and negative aspects of science and technology. He depicts the applied sciences of surgery, pharmacy, agriculture, chemistry, and weaponry. His representation of theoretical science extends back to the ancient Greek concepts of Earth, Fire, Air, and Water and proceeds through the 19th century debate in geology over the role of fire and water to the 20th century discussion of the origin of life and the mechanism for the synthesis of life. These murals, and Rivera's art in general, can be used in the teaching of geology, biology, chemistry/ biochemistry, medicine, and technology, either as a starting point for discussion or for enrichment and integrative purposes in discussing the similarities and differences between the creative processes in science and in art. A slide set of the murals is available for purchase at the Detroit Institute of Art. Rivera murals can also be found in other parts of the United States, and field trips can be arranged in these areas.

--Botany and Mesoamerican designs. Designs on small clay spindle whorls and stamps found in some archeological excavations in Mesoamerica reveal a variety of floral and fruit structures. Spindle whorls (malacates) are 2-5 cm diameter clay discs from the bottom of the spindle used for spinning maguey, cotton or wool fibers. The stamps are 1-23 cm long incised clay artifacts, wich were probably used to print designs on another surface. The designs closely resemble sections of fruit (pepper, squash and tomato) and radially symmetrical botanical diagrams of flowers. Class activities in biology can begin with an art project or end with an art project. These designs can be used to learn flower structure, to learn floral diagrams, to observe various fruits in sections, to compare Mesoamerican designs with European floral diagrams, to discuss whether or not the representations from each culture are of the same objects, and to learn which of the examples of the fruits were domesticated in the "new world."

--The chemistry of color. Dyes from native plants can be extracted for beginner's chemistry to study color and color production. The plants can be grown or collected and classified into groups using different criteria. The dyes extracted can then be used in an art project.

SUMMARY

There are many ways in which science can be made culturally relevant. Archeoastronomy, mathematics, geology, ethnobotany, chemistry, and art all can be taught from a perspective which celebrates the accomplishments of Mexican American and American Indian science and encourages exploration. Stimulated by such an approach, students who have typically not been attracted into scientific careers will perceive new possibilities.

FOR MORE INFORMATION

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