The Science–Mathematics Connection

Using technology in an interdisciplinary module

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Instruction in a culturally diverse environment requires a variety of skills and classroom experiences that incorporate integrated, standards-based curricula. To achieve equity, teachers must develop an all-inclusive conceptual framework that gives all learners adequate access to learning resources. To achieve these goals, we participated in a workshop using technology-based modules that emphasize multicultural instructional activities, materials, tools, and assessment for integrating concepts in Earth science, algebra, geometry, and statistics.

Earth science involves the study of interactions among the Earth's atmosphere, biosphere, hydrosphere, and geosphere. Traditionally, this topic is taught in middle and secondary curricula, where integrating concepts across discipline areas, such as mathematics and science, provides global perspectives for addressing issues concerning multiculturalism in instruction and learning.

Effective teachers use a variety of instructional strategies to work with students from various racial and ethnic groups (Cordiero et al, 1994). The *National Science Education Standards* (National Research Council, 1996) and the National Council of Teachers of Mathematics standards (2000) provide guidelines for designing integrated curricula and materials. In both cases, these standards strongly recommend the implementation of interdisciplinary instructional activities for all students. Linking Earth science and mathematics concepts, for example, allows students to see the relevance of both academic disciplines and to gain unified knowledge and skills that make sense in the real world. Efforts to enhance students' career awareness, such as providing examples of scientists from many cultures and disciplines, is an essential ingredient of culturally diverse curricula and allows students to perceive cultural inclusion.

In a multicultural educational environment, instruction should begin and end with the students (Barba, 1998). In fact, the teacher's understanding of students should form the basis of instruction (Lapp et al, 1989; National Council of Teachers of Mathematics, 1991)). Teachers must recognize the need for culturally responsive pedagogical practices that address the needs of all students (Figure 1, page 64).

A global module

The Science Teachers Open Support System (STOSS), a three-year program funded by the National Aeronautics and Space Administration, was designed to assist African American middle and high school teachers in designing and implementing technology-based interdisciplinary science and mathematics modules for culturally diverse student environments. The primary objective of the program was to design instructional activities, tools, and assessment

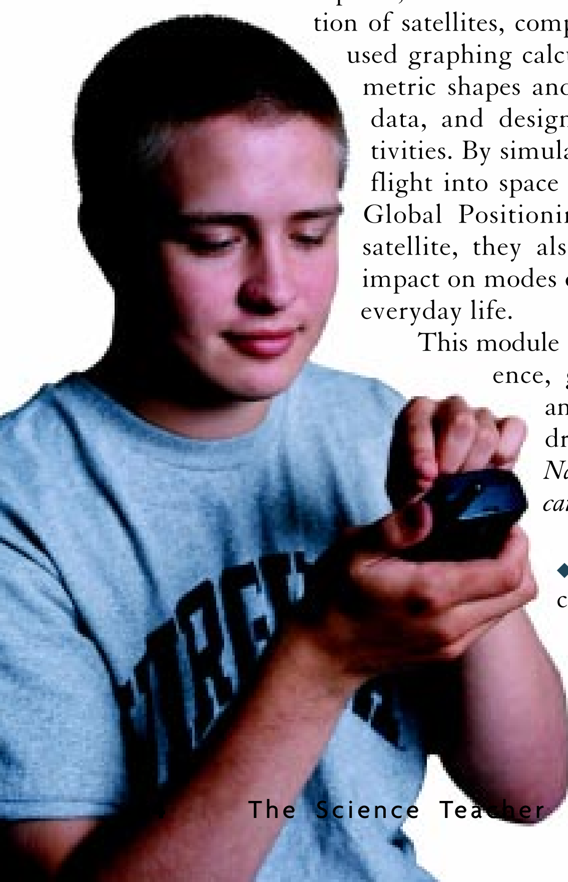
FIGURE 1

Strategies for engaging students in multicultural learning activities.

- Designing interactive bulletin boards that feature photographs, biographical profiles, and explanations of contributions of scientists from various cultures.
- Conducting Internet searches for accomplishments in science and mathematics by people from underrepresented populations.
- Composing graphic organizers and concept maps of culturally historic milestones in science and mathematics.
- Implementing models of authentic assessment using culturally diverse resources.

strategies that integrate principles of Earth science and mathematics. Forty-eight teachers from a variety of schools in Georgia participated.

The interactive component of STOSS was a summer institute, where we designed multicultural, integrated science and mathematics modules. One such module, "Comets, Satellites, and Global Positioning Systems," takes about three days to complete and teaches students to identify technological devices and resources for studying the Universe. Teacher–participants constructed a model planetarium (Figure 2), plotted various polygons in the Cartesian plane, observed and discussed the motion of satellites, compiled Internet data, used graphing calculators to plot geometric shapes and analyze statistical data, and designed assessment activities. By simulating an astronaut's flight into space to reposition a lost Global Positioning Systems (GPS) satellite, they also researched their impact on modes of transportation in everyday life.



This module integrates Earth science, geometry, algebra, and statistics, and addresses the following *National Science Education Standards*:

- Earth science content standard (communicates problems, processes, and solutions);
- History and nature of science (science as a human endeavor); and
- Personal and social perspectives (science and technology in local, national, and global challenges).

The following National Council of Teachers of Mathematics (2000) standards are also addressed:

- Problem solving—solve problems that arise in mathematics and in other contexts;
- Connections—recognize and apply mathematics in contexts outside of mathematics;
- Geometry—use visualization, spatial reasoning, and geometric modeling to solve problems;
- Algebra—use mathematical models to represent and understand quantitative relationships;
- Representation—use representations to model and interpret physical, social, and mathematical phenomena; and
- Data and probability—select and use appropriate statistical methods to analyze data.

To make "space flight" more appealing to students, we built a model planetarium in which the student designated as the astronaut would go to get the GPS satellite back in its orbit. The class was divided into three groups. The groups simulated GPS receivers located in three different media as follows: Group 1 in the air (aboard an airplane), Group 2 in water (aboard a submarine), and Group 3 on land (in a television station). Each group designated an astronaut to travel into outer space aboard the planetarium, a recorder to write down all lab data, and a navigator to communicate with astronauts aboard the planetarium. To augment the use of walkie-talkies, we designed a pulse code chart of specific navigational codes for transmitting satellite coordinates between the astronauts and the navigators.

The astronauts and navigators for each group received a pair of walkie-talkies and copies of the pulse code chart. The astronauts for each group were also given the respective discrete air, water, and land coordinates (in writing) needed to complete the mission. Figure 3 (page 66) is a summary of the coordinate pairs given to each group astronaut, and Figure 4 (page 66) is a copy of the pulse code chart.

We purposefully chose coordinate pairs that represented the vertices of polygons. However, astronauts did not receive this information. No verbal transmission of the coordinate pairs was permitted—the astronaut and navigator used only the pulse code chart with the walkie-talkies to send the coordinates. However, astronauts used "the following are codes for the x axis" or "the following are codes for the y axis" to initiate the transmissions. The astronauts also received a flashlight for use inside the planetarium.

FIGURE 2

Planetarium construction directions.

We used one 15 m roll of black construction plastic of 6 mm thickness, one large roll of wide black duct tape, scissors, one package of straight pins, one 30.48 m metal measuring tape, and one square electric fan. To complete the experiment and class discussions we also needed three pairs of walkie-talkies, three flashlights, one overhead projector, transparencies of graph paper, blank overhead transparencies, fine-tip transparency pens, graph paper, rulers, and graphing calculators.

To construct the body of the planetarium, we measured and cut a 12 x 3 m rectangular piece of the black construction plastic. After cutting, we smoothed out all creases and folds and then folded the plastic in half lengthwise into a 6 x 3 m, double-ply rectangular shape. Using duct tape, we securely sealed the edges along one of the 6 m sides by first placing one edge on top of the other. We then sealed the remaining 6 m side in the same manner, and left the 3 m edge unsealed. We then had a large rectangular plastic bag opened only at the 3 m side.

To construct a wind tunnel for the planetarium, we measured the perimeter of the electric fan and cut a second piece of the black plastic about 1.5 m long and as wide as the perimeter of the fan. Again, we smoothed out all folds and creases and then folded this piece in half lengthwise. Using duct tape, we securely sealed the 1.5 m side. We did not tape the remaining two sides, but placed one end of the tunnel about 0.25 m into the open end of the planetarium flush against one side. We securely taped and sealed the body of the planetarium all around the tunnel. This prevented wind seeping from the interior of the planetarium. We securely taped the remaining end of the completed tunnel around the perimeter of the fan, remembering to allow the fan to blow into the body of the planetarium (only the back of the fan was visible from outside the planetarium).

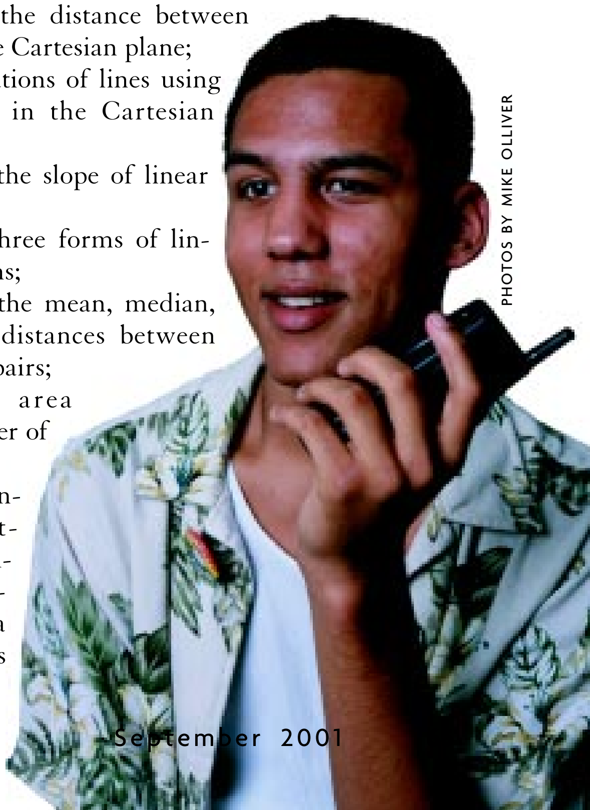
We plugged in the fan and turned it to the highest speed. The planetarium inflated in a few minutes. We moved approximately 3 m away from the fan along the body of the planetarium and used scissors to make a 1.5 m slit, from top to bottom, for a door. Finally, we used straight pins to randomly poke holes in the ceiling of the planetarium to simulate stars. The model planetarium was thus completed.

The experiment began after the three astronauts entered the planetarium (or darkened room if it is not possible to construct the planetarium). Remaining group members moved about 25 m away from the astronauts (but within range of the walkie-talkies) to prevent the astronauts hearing communications between the navigators and recorders. We confirmed readiness to begin, and the astronaut for Group 1 (air) began transmitting the coordinate pairs to the navigator for Group 1. The navigator confirmed each pair by sending them (one pair at a time) back to the astronaut. The astronauts' simulated resetting of each pair was confirmed with the transmission of a "completed" code (see pulse code chart) back to the navigator who, in turn, verbally relayed each pair to the group's recorder. The recorder plotted each coordinate pair on graph paper and connected them with line segments. The procedure was complete after each astronaut had transmitted all coordinate pairs for the group and the recorders had finished their graphs.

Assessment

Assessment activities included group presentations of the information the teacher–participants compiled from their Internet research on comets, GPS, and satellite systems. Using the data they recorded and analyzed during the experiment, each group:

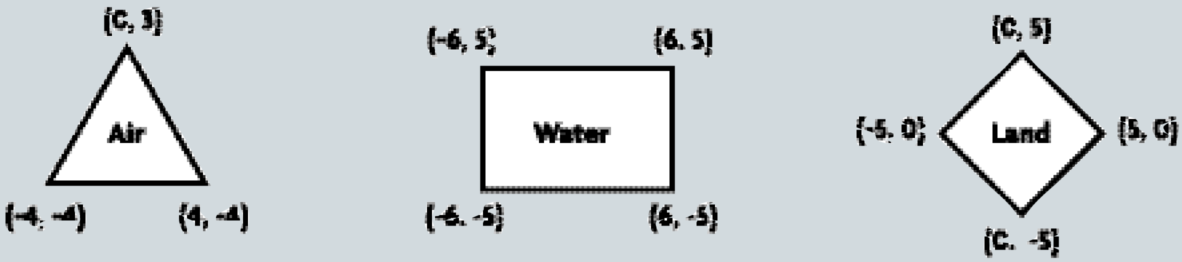
- Identified and discussed the characteristics of geometric shapes/polygons;
- Classified geometric shapes according to number of sides;
- Plotted polygons in the Cartesian plane both manually and using graphing calculators;
- Calculated the distance between points in the Cartesian plane;
- Wrote equations of lines using two points in the Cartesian plane;
- Calculated the slope of linear equations;
- Identified three forms of linear equations;
- Calculated the mean, median, and mode distances between coordinate pairs;
- Computed area and perimeter of polygons;
- Used presentation software to summarize statistical data in tables



PHOTOS BY MIKE OLLIVER

FIGURE 3

Geometrical shapes with cartesian coordinates.



and charts and to compile reports; and

- Identified and discussed the contributions of various ethnic and cultural groups to the development of science and mathematics.

Instruction in the culturally responsive, integrated curriculum must reflect the rapidly changing characteristics of our society. To accomplish this task, participants in the STOSS program used technology as the foundation for researching culturally diverse contributions to the development of science and mathematics, for analyzing legitimate data, and for assessing students' content knowledge. STOSS participants were confident about implementing, in their classrooms, what they learned during the summer institute. Each teacher accepted the responsibility to channel an optimistic view of the multicultural approach to teaching and learning in their respective schools and to assist in affecting positive change in their students' attitudes about science and mathematics.

FIGURE 4

Pulse code chart (to be used by astronauts and navigators).

*	= short pulse
//	= long pulse
0	= //
-1	= //*
1	= *
-2	= //**
2	= **
-3	= //***
3	= ***
-4	= // ****
4	= ****
-5	= // *****
5	= *****
-6	= // ******
6	= ******
Completed	= // //

As national standards for teaching science and mathematics continue to accentuate the need to connect, represent, and solve problems that exist in the real world, coordinators of the program recognized the need for appropriate methods and materials that address the needs of all students.

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