Mathematics Across the Curriculum

In the Journeys in Mathematics project, teachers engage children in imaginative activities that inspire them to learn how to identify patterns and relationships, solve problems, and communicate accurately.

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We often hear of writing across the curriculum and the writing process, reading in the content areas and whole language approaches to reading. But rarely, if ever, do we hear of mathematics across the curriculum, the math process, mathematics in other content areas, or whole math approaches. Except for its relationship to science, mathematics is the forgotten cousin in interdisciplinary teaching and learning.

Efforts to integrate mathematics with language arts, social studies, history, art, or music are rare indeed. And as teaching in many subject areas moves toward more process-oriented, holistic, and collaborative approaches, mathematics is often left behind with its traditional workbooks, drills, and tests.

The neglect of mathematics in the movements toward interdisciplinary curriculum and new approaches to teaching stems in large part from misconceptions about mathematics that pervade our schools and our society. Many people see mathematics as isolated from other areas of study, irrelevant to everyday life, and devoid of creativity and aesthetics.

Learning mathematics is seen as memorizing facts, formulas, and procedures—as simply absorbing knowledge that has been handed down for generations. Many people believe that students must spend years learning formal mathematics before they can begin to think mathematically and use mathematics productively, and that only students with special talents can become mathematically proficient. Mathematics is thought to be its own world, accessible to only a select few, and, except for basic computation, of little relevance or use for most people.

The Humanistic View

This *dehumanized* view of mathematics is erroneous. Mathematics is, and always has been, essential to the human experience. Without mathematics, as without language, the nature of humanity and human society would have to be fundamentally different.

To be human is to seek to understand. Mathematics, along with science, has made possible dramatic advances in our understanding of the physical universe. To be human is to explore. Throughout history, mathematics has been essential for exploration, from navigating by the stars to travel into space. To be human is to participate in a society. Societies require mathematics to keep records, allocate resources, and make decisions. To be human is to build, and mathematics is essential for the design and construction of everything from tents to temples to skyscrapers. To be human is to look to the future. Mathematics enables us to analyze what has been, predict what might be, and evaluate our options. To be human is to play, and mathematics is part of our games and our sports. To be human is to think, to create, and to communicate. Mathematics provides a vehicle for thinking, a medium for creating, and a language for communicating. Indeed, to be human is to develop mathematics. Mathematics has been developed in every culture for the purposes of counting, locating, measuring, designing, playing, and explaining (D'Ambrosio 1985, Bishop 1987, Gilmer 1990).

Viewed from this perspective, what we often teach students is an impoverished mathematics, one that focuses on detailed facts and procedures while neglecting the fundamental nature and value of the field. If we taught music as we teach mathematics, students would practice musical scales for years without ever getting to play a song. If we taught art as we teach mathematics, students would practice drawing lines and shapes for years without ever getting to create a picture. And if we taught writing as we teach mathematics, students would practice spelling, punctuation, and penmanship without ever getting to use writing to express what they have to say.

Travels with Gulliver

In the Journeys in Mathematics project at the Education Development Center, we have developed a curriculum unit for grades 4–6, called *My Travels with Gulliver*, which integrates mathematics with literature, writing, and drawing. In this unit, students read stories that incorporate mathematical concepts and they use mathematics to enhance their understanding of the stories and to create their own stories and drawings.

My Travels with Gulliver incorporates two stories. One, written specifically for the unit, begins with two students, Shaun and Tam, and their Aunt Linnea, who discover an old trunk that contains letters, maps, and mementos that belonged to the adventurer Lemuel Gulliver. These three characters learn about Gulliver's visit to Lilliput, the land of tiny people, from the letters and drawings in the trunk. They find a map and magic stone in the trunk, and they travel to Titania (a land created for this unit) where everything is four times the size of comparable things in Ourland (the name used in the story for the land in which we live).

The second story is "Gulliver's Voyage to Brobdingnag," from Jonathan Swift's classic book, *Gulliver's Travels*. Students listen to a recording of Gulliver's adventures in this land of giants. Swift's story provides information about the sizes of many things in Brobdingnag, where people and objects are 10–12 times as large as similar things in Ourland.

"Gulliver" Activities

These two stories motivate mathematical explorations, creative writing, drawing, and discussions. Here are some sample activities:

- Students measure actual-size tracings of people, animals, and things from Lilliput. They use their measurements, and measurements of things in Ourland, to estimate the sizes of other things in Lilliput. For example, they measure a tracing of a typical 12-year-old Lilliputian child and find it to be 4.5 inches tall. How large, then, would a child's desk be in Lilliput? How large would a Lilliputian classroom be? The child's mother and father?
- When listening to Gulliver's adventure in Brobdingnag, students collect information about the sizes of things in this land of giants. They find, for example, that a Brob farmer holds Gulliver 60 feet from the ground, a hedge is 20 feet high, a stairstep 6 feet high, and a serving dish 24 feet across. They use this information to determine the *scale factor* that relates the sizes of things in Brobdingnag to the sizes of things in Ourland and to discuss which things are in standard sizes and which come in a range of sizes.
- When students meet Glumdalclitch, a 9-year-old Brob girl who takes care of Gulliver, she is described as "small for her age, not over 40 feet tall." This leads to the question of what around us is about as tall as Glumdalclitch. Students seek ways to estimate the heights of such things as buildings, trees, and flag poles to get a concrete sense of the sizes of people in Brobdingnag.
- Students make actual-size drawings of objects from Titania and Brobdingnag. For example, they might make giant pencils, calculators, or books. After students meet Weldren, a Titanian girl, each student draws one part of her face—her eyes, nose, mouth, ears, and hair. Students then combine the parts and draw her head. Making these drawings involves careful measurement of each part of the object and the use of strategies for rescaling shapes. Combining the parts of Weldren's face provides a ready check of whether each student did his or her work accurately.
- The drawing activities lead to considering perimeter and area. How much

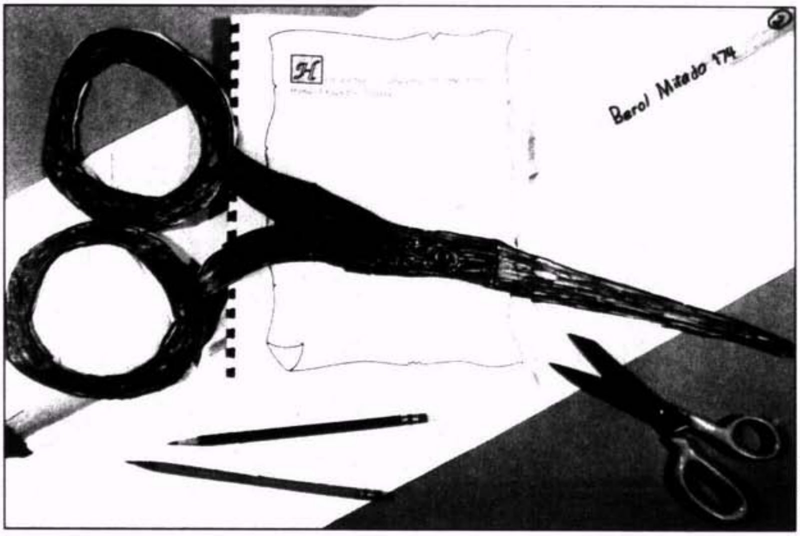
material would it take to frame each drawing? How does this relate to the amount of material needed to frame an actual-size drawing of the Ourland object? How many of the Ourland objects are required to completely cover the Titanian-size drawing? Is it the same number no matter what object was drawn?

• There are many opportunities for creative writing within the unit. Students create their own adventures in Lilliput, Brobdingnag, and Titania. They write about visits to Ourland from Glumdalclitch and Weldren. They use information about measurements and size relationships to make their stories realistic and accurate.

Creating New Lands

At the end of the unit, students create their own lands. They describe the sizes of things in their land, write stories about the land, draw pictures, and create travel brochures to encourage people to visit their land. One student wrote about visiting a Brob classroom:

> I was walking toward the front of the Brob classroom, hoping that the teacher would notice me. A giant log was in my way. I suddenly realized that the log was really a pencil that one of the young "Brobs" had dropped, for in a matter of seconds, a five-foot-long hand reached down to the floor. It began scrambling around, trying to find the pencil. Suddenly, the hand seized me by my knees! "I'll use this stubby pencil," the Brob murmured, as it brought me up to the desk. I wanted to scream, but I couldn't get hold of my voice. Without even looking at me, he (now I knew it was a he) absentmindedly started to doodle on a piece of paper, using my feet as a tip. As the teacher walked by, he rapidly turned me around, and used my head as the eraser. "Ouch!" I yelled. Shocked, he dropped me. I can't believe I actually survived the 28 foot drop from the desk to the floor!



Marlene Nelson

After collecting information about the sizes of things in Brobdingnag, the land of giants, a student used his math skills to create the King of Spades on page 49. Above, a Brobdingnag-sized pair of scissors.

Another described a walk along a Brob street:

> I was walking along one of Brob's huge sidewalks which was like walking in a gigantic Logan airport. Suddenly I bumped into something. It was a Pepsi can four feet, two inches—up to my chest. I figured out a way to get by it, somehow, and I found myself stuck on a piece of bubble gum bigger than my foot! I was about to step and I saw a two foot, six inch long, five inches high log. What was it? A cigarette! My does this place have litter!

Other students created life-size pictures of objects from the lands of giants.

These activities and student work illustrate how mathematics can be well integrated with literature, writing, and drawing—areas that are often thought to be nonmathematical.

Units for Middle Schools

In a new project, Seeing and Thinking Mathematically, also funded by the National Science Foundation, we are developing a middle school mathematics curriculum that will include a variety of interdisciplinary activities.

For example, the unit *Yesterday and Tomorrow* will involve students in researching data about changes in years past, identifying trends or patterns in the data, and making predictions about the future. Students might analyze the changes of their town's population and the relationship to the number of cars, businesses, schools, and so on. This unit will involve students in mathematics concepts such as linear, cyclical, and exponential change.

The unit *Designing Spaces for People* will involve students in measurement and design. Students might take part in such projects as planning ramps that would provide access to people in wheelchairs. Considering how long a ramp should be will lead into mathematical explorations of angle, slope, ratio, and similar triangles.

Other units will focus on the mathematics of such areas as maps and mapmaking (measurement of distances and scale), art (perspective drawing, concepts of symmetry and balance), sports statistics (averages, percentages), and decision making (probability of outcomes).

Connecting Mathematics to Experience

Viewing mathematics within the human experience leads to mathematics teaching that shares many basic principles with the writing process approach.

Both are based on "holistic" views of learning—that children should start with real goals and accomplish real tasks from the beginning, and that the learning of specific skills and facts should take place within the context of these tasks. The writing process begins with the central function of writing—for the individual to express and communicate his or her own experiences, thoughts, and feelings. The mechanics of penmanship and the details of punctuation, spelling, and grammar serve this larger, holistic function, rather than being ends in themselves. Likewise, mathematics instruction can begin with the central functions of mathematics—to identify and represent patterns and relationships, to solve problems, and to communicate precisely. The mechanics of algorithms and the details of facts and formulas *serve* these functions.

Mathematics, like writing, can build upon what young children already know and do. In writing, the basis is the child's general experience and ability to communicate in speech or sign language. In mathematics, the basis is the child's experience with actions such as combining, sharing, and comparing, the child's developing concepts of time and space such as *before* and *after* and *near* and *far*, and the child's natural recognition of visual, musical, and movement patterns.

When mathematics is connected to the human experience, the same type of classroom culture advocated in the writing process—one that supports collaborative work, discussion and sharing of ideas, mutual respect for each learner's approach, and students' sense of ownership of their work—becomes essential for mathematics learning. The teacher's role within this culture is not the knowledge-giver of the traditional mathematics classroom, but rather a facilitator of students' learning and a participant in using and discussing mathematics.

Mathematics provides a language for quantifying, measuring, comparing, identifying patterns, reasoning, and communicating precisely. This language, like English or any other natural language, can provide a means for understanding, analyzing, and communicating across the curriculum and throughout students' lives. It's a language children can bring into the worlds they create. □

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