The Librarian Who Measured the Earth

The Librarian Who Measured the Earth, by Kathryn Lasky (1994), a biography about Eratosthenes, offers interesting highlights of his life, focusing on how he questioned and eventually found the measurement for the circumference of the earth. Eratosthenes became the librarian in Alexandria, Egypt, at a time when Alexandria was the home of scholars. With access to all the records in the library and to other scholars, Eratosthenes was able to explore and solve numerous problems in many areas, including geography and mathematics. This beautifully illustrated book emphasizes that Eratosthenes was a questioner and a problem solver.

The mathematics that Eratosthenes used can prompt a powerful investigation into circles and triangles. In this lesson, students examine the relationship between central angles of a circle and its circumference. Students measure the central angle and the arc length it creates and then estimate the circumference of the circle using that information.

MATERIALS

spherical object such as a basketball or a beach ball

cardboard circles of various sizes, 1 per small group of students

pieces of string, about 1 foot long, 1 per small group of students

protractors or angle rulers, 1 per small group of students

rulers marked in centimeters and millimeters, 1 per small group of students

***The Librarian Who Measured the Earth* record sheets,** 1 per small group of students (see Blackline Masters)

calculators, 1 per student

The Investigation

To introduce this lesson, hold up the ball and ask students how they might determine its circumference. It is likely that they will suggest wrapping a tape measure or string around the ball at its widest place. Ask students if they can imagine ways to measure a really large sphere; ask if they have ideas about how the earth and other planets were measured. Read the book to the class. If time is limited, start with the passage on page 30, where the detailed discussion of the earth's circumference begins.

After finishing the book, ask students, "Do you think that you can use Eratosthenes's approach to find the circumference of different-sized circles?" Place students in groups. Give each group one cardboard circle, a piece of string, a protractor or angle ruler, a ruler, a pair of scissors, and a record sheet. Also make sure that each student has a calculator. Then ask each group to name and secretly measure the circumference of its circle, as carefully as possible. Depending on the experience of the students, they can determine circumference by direct measurement or by measuring the diameter or radius and using the formula. Ask each group to find the center of its circle and, using the protractor (or angle ruler), create a sector with an angle measure between 5 degrees and 45 degrees, cut it out, and name it, so later on the students will know it is their section.

When groups are ready, have each group pass its sector to another group. Tell the groups to determine the circumference, to the nearest hundredth of a centimeter, of the circle the sector belongs to. They can do this by reversing the process they used to create their sectors. They must determine the arc length and the angle measure of the sector (see table on record sheet). Have students repeat this process two or three more times, passing on the section they have for a new section from another group. With each new sector, ask students to rotate their jobs—who measures the angle, who measures the arc, who determines the circumference, and who records the data in the table.

As the groups are working, prepare a list of the names of the circles with the actual circumference measurement for each as determined by the group that started with that circle. Once all groups have worked with four circles, ask them to predict how accurate they think their work is. Questions might include:

- How accurate do you think your circumferences are? (for example, within how many centimeters or millimeters?)
- Do you think that smaller circles will have more, less, or the same error of measurement that bigger circles have?

- If a circle measured 20 centimeters around, but you approximated it to be 19 centimeters, what would be the percent of error? ($\frac{1}{20}$ = 5 percent error)

Post the actual measurements for the circumferences of the circles. Ask students to find the percent of error in their work. After students have done this, ask them what could have caused the errors. Students might suggest cutting errors, measurement errors by the original measurers or their group, and rounding errors. Return to the story, reminding students of how Eratosthenes measured the arc length. Ask students to determine his percent of error in his measurement (see page 44 of the book for the values needed).