Exploring Maps — Location

How do we know where we are?

For the most part we sense our surroundings visually. We may see canyons, rivers, sand dunes, mountain peaks, schools, roads, or other ***landmarks***: we understand our surroundings as a collection of visible features.

We also think of places in terms of other places. For example, you know where you live relative to friends' houses, school, and so forth. From downtown to the boondocks, distances and directions to other significant places for part of our understanding of places in the world. In a larger way, we have also come to understand the relationship between our surroundings and the Sun, Moon, and stars by carefully observing the changing sky.

A great number of devices have been invented to measure places. The first tools, invented thousands of years ago, were simple gadgets: the level, the sight, the measuring chain. Mathematics developed geometry to describe shapes and relationships of objects in space. The ***magnetic compass***, the ***sextant***, the telescope, the ***theodolite***, the ***planetable***, and the ***marine chronometer***, used in combination with mathematics, have greatly increased mapping accuracy.

Developments in mapping continue today with advances in computer hardware and software, lasers, and satellites, which carry ***remote sensing*** devices around the earth and to distant places in the solar system.

Technological innovation and the advancement of science have gone hand in hand. The development of agriculture eventually led to land ownership, which led to ***surveying*** and taxes.

In the third century B.C., the Greek astronomer and mathematician Eratosthenes used observations of shadows and distances to calculate the circumference of the Earth. His calculation, about 25,000 miles, was accurate to within 500 miles.

Observations of stars, planets, and other objects in the sky, meanwhile, were being recorded with great accuracy (as shown, for example, on the 1193 Suchow ***Planisphere***), changing people's understanding of the relationship of the Earth and the heavens.

Local measurements of distances and direction provided detailed information about small areas; little by little, this information was compiled on less detailed maps of larger areas (for example, the 1109 Beatus map, the 1452 ***Mappa Mundi***, and the 1502 Cantino Planisphere), presenting broader views of the Earth as it was thought to be. Many of these old maps, however, also include conjecture and decoration, without distinguishing between the known and the unknown.

As mapping entered the Renaissance, European navigators used the magnetic compass in navigation, developing ***portolan charts***. In the late 1600's, surveyors improved accuracy by using Galileo's telescope and a technique called ***triangulation***. In this process, the location of a new point is determined by measuring a distance between two known points and measuring angles from each end of this line to the new point.

Although solar observations were useful for measuring distances north and south (***latitude***), accurate measurement east and west (***longitude***) was not possible until 1765, when the marine chronometer was introduced. This was the first precise portable clock unaffected by the rocking motion of ships.

Beginning in the 19th century, photography and the aerial viewpoint revolutionized mapping. By the 1920's, aerial photographs were found to be excellent mapping tools, especially when viewed through the stereoscope, revealing a three-dimensional image. ***Photogrammetry*** and remote sensing from satellites and airplanes have extended the mapper's view to distant planets and beyond.

Exploring Maps — Location

Activity 1:
Tools of the Ancients

This pair of exercises introduces students to two tools that make observations of the Sun. Each exercise is a group activity to help students see how tools were used to collect geographic data. These new data contributed to a better understanding of the relationships between places.

How Columbus Determined His Latitude

Columbus used navigational tools to determine his ship's position, keeping track of` his progress on charts of the seas or world maps like the 1482 map by Ptolemy, the best at the time. Columbus determined the latitude of his position by measuring the height of the sun above the horizon. (He determined longitude by ***dead reckoning***.)

Time:

One 50-minute class period.

Materials for each group of four students:

- Drafting triangle or ruler Protractor
- String (12 inches long)
- Tape
- Paper clip
- Quarter
- Notebook and pencil

Procedures:

1. Make an instrument to observe the height of the Sun above the horizon, as follows:

a. Tape a protractor to the side of a triangle, aligning one outside edge of the triangle with the zero point and 90-degree mark on the protractor, as shown in illustration A.

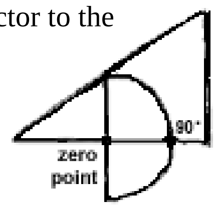

Illustration A

b. Clip the paper clip onto the quarter and tie the paper clip to the end of the string.

c. Tape the string to the protractor so that it hangs freely from the zero point, as shown in illustration B.

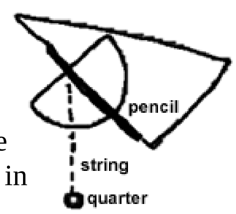

Illustration B

d. Align the pencil with the zero point and 90-degree mark on the protractor and tape it in place, as shown in illustration B.

2. Take observations when the Sun is highest in the sky, which is generally within a half hour of noon. The analemma (illustration D) shows the variation between solar noon and noon according to standard time on the clock. If you are in a time zone observing daylight Savings time, the Sun will be highest an hour later.

3. To take a reading on the Sun with this instrument, *do not look directly at the sun*; observe the shadow of the instrument. Stand on pavement or another smooth surface (not grass). One student holds the instrument a few feet above the ground so that the pencil points directly at the Sun and the string hangs freely next to the protractor. Looking at the shadow on

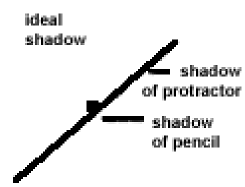

Illustration C

the pavement, the student moves the instrument until its shadow appears as a line (from the triangle and protractor) with a dot (from the pencil), as shown in illustration C.

The other students take turns reading the angle between the string and the 90-degree mark on the protractor, and recording this angle in their notebooks. The readings will probably differ, so the group compares them and settles on the best value. It may be best to discard the highest and lowest readings and average the other values.

4. To determine the latitude, adjust this number, representing the angle, to correct for the tilt of the Earth's

Exploring Maps — Location

axis. The adjustment changes with the seasons. Use the analemma (illustration D) to determine the correction needed. For observation in the Northern Hemisphere, the Sun appears lowest in the sky in late December; at this time, add 23.5 degrees to the reading; at the summer solstice in June subtract 23.5 degrees from the reading. Intermediate adjustments for readings between these dates can be estimated from the analemma.

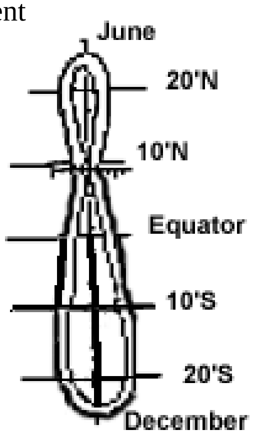

Illustration D

Extensions:

1. Construct a scale model of the solar system showing relative sizes of planets and distances from the Sun.

2. Discuss what might have happened had Columbus used Eratosthenes' measurement of the Earth's circumference.

3. Look more closely at the analemma. Why does the length of the day vary?

Local time and "Grinnage time"

In the quotation from *Tom Sawyer Abroad*, Tom tries to explain to Huckleberry Finn that time differs around the globe. Local noon time once was determined by measuring the highest point in the Sun's daily arc, so that local time varied from east to west. In the late 1800's, time zones were established to help standardize time. The sundial shows the relationship between local time and standard and daylight savings time.

Time:

15 minutes preparation (steps 1-3). Nine 10-minute observations, mostly concentrated around noon. 15-30 minutes discussion after observations are made.

Materials for each group of four students:

- One pole about 3 feet long to hammer into the ground or a free-standing pole with a pointed top (you can use an old antenna or a gate post with a pointed top)
- A "do not disturb" sign to mark the experiment area
- String about 15 inches long with a weight at one end
- Nine 1- by 2-inch pieces of scrap paper labeled with the observation times
- Nine stubby pencils
- Protractor
- Measuring stick or tape
- Notebook and pencil

Materials in the classroom:

• Blackboard on which to draw a scale model of your sundial

Procedures:

1. Working as a class, choose a flat spot where the Sun will not be blocked during your observation period. Beware of shadows from trees and buildings.

2. Set up the pole, being careful to make it vertical; using the string with the weight on the end as a plumb bob, check to be sure the pole is vertical. The pole should be placed firmly enough to remain in position throughout the day. Measure the height of the pole and record the measurement in the notebook.

3. Label the scraps of paper with the times you will take observations, such as at 10, 11, 11:20, 11:40, 12, 12:20, 12:40, 1, 2. Plan observations to be as symmetrical as possible around local noon. Note that during daylight savings time, local noon is delayed one hour. Find your location on a map that shows time zones; the closer to a time zone boundary, the greater the difference between local noon and noon according to the clock.

4. Divide the class into groups of three to take observations. A pair of students marks the position of the end of the pole's shadow.

One student (the observer) pokes a pencil stub (point down) through the piece of paper labeled with the time and holds it on the ground such that the point of the pole's shadow falls on the hole where the pencil goes through the paper. The second student (the recorder) verifies the position, and the observer pushes the pencil in the ground.

The third student (the measurer) then measures the length of the shadow from the base of the pole to the pencil; the recorder records this in the notebook with the time. The measurer then uses the protractor to measure the angle between the shadow and its previously observed position, which the observer marks by stretching the string from pole to respective pencil; the recorder writes this value in the notebook.

Be careful during observations not to move the pole. Observations and measurements should be made quickly but carefully; 3 minutes should be enough time.

5. Back indoors, record the various measurements on the blackboard on a scale drawing of the sundial.

6. After your last observation of the day, ask the class to determine the time when the Sun was at its highest. This is local noon.

7. Discuss the difference between local noon as measured by the sundial and as indicated by the clock.

Extensions:

1. Notice that the sundial becomes a compass at local noon—that is, the shadow at local noon points to the Geographic north pole. Using a compass, find the difference between geographic north and magnetic north. Experiment with the magnetic compass and map use. Discuss orienteering. (Information is available in such publications as the Boy Scout Handbook and the USGS fact sheet *Finding Your Way With Map and Compass* available online at http://mapping.usgs.gov/mac /isb/pubs/factsheets/fs07999.html.)

2. Using geometry, calculate the width (in degrees) of a time zone. With this information calculate your longitude by comparing your time with time in Greenwich, England.

Activity II: A Place in Time

In groups of two, select a place to study, and note how it has changed over time. Choose an old city near you or a famous place anywhere.

Time:

Two 50-minute class periods.

Materials for each pair of students:

- Books, articles, maps, photographs, and other information about the history of your place
- Continuous-feed computer paper (about 6 feet long)
- Scissors
- Tape
- Markers

Procedures:

1. Study the history of a place. Find out who settled there, when, and why. How did they make a living? Who else did these people have contact with? As time passed, when and how did the place change? When, why, and how did the population grow? How did the relationship between this place and the surroundings change? How did this place function in the context of the immediate area and in the world? How did this function change? How did world events affect this place?

Exploring Maps — Location

2. Make a timeline on which to record information you collect about the place from its founding to the present. Summarize the history of the place by dividing its history into periods and labeling the periods.

3. Illustrate the timeline with sketches or photographs from newspapers, magazines, or other sources.

4. On a base map of the area, sketch a map of the place for each period.

5. Display timelines all review them for aspects of effective presentation: color, lettering size, organization, size and style of maps, etc.

Glossary:

dead reckoning

Greenwich time

landmark

latitude

longitude

magnetic compass

mappa mundi

marine chronometer

photogrammetry

planetable

planisphere

portolan chart

remote sensing

sextant

surveying

theodolite

triangulation

Additional activities:

1. Invite a surveyor to demonstrate today's tools to the class.

2. From the information on the poster, select two quotations that seem especially pertinent to this activity sheet, and write an essay that discusses the ideas of both writers.

Recommended reading:

Boorstin, D.J. *The Discoverers*. New York: Random House, 1983.

"Finding your way." *Boy Scout Handbook, tenth edition.* Irving, Texas: Boy Scouts of America, 1990, 179-211.

Finding Your Way With Map and Compass. U.S. Geological Survey Fact Sheet 079-99, 2000.

Morrison, Phillip, and Morrison, Phylis. *The Ring of Truth*. New York: Random House, 1987.

Wilford, J.N. *The Mapmakers.* New York: A.A. Knopf, 1981.