The Secret (Magnetic) Number

Activity using Magnetic Declination

Based on *Magnetic Magic*

What "magic" trick can be used as a launching point for discussions on magnetism, the magnetic vs. geographic poles of the earth, the discovery of the new world and the theory of plate tectonics? A lodestone!

I. Introduction
   A. In this activity students will use lodestones to determine magnetic North and differentiate it from true or geographic North. They will then 'hide' a treasure and device a map to find it using pre-determined compass bearings. After creating a map for this school year, students will adjust the directions to correspond to a map made 100 years ago. Cross-curricular ties included for discussion.

II. Concepts:
   A. The earth is a magnet. It has a magnetic field. The magnetic field is created by the movement of charged particles in the liquid outer core which is inside the crust of the earth. The movement of the charged particles generates an electric current and the electric current, which surrounds the earth's solid iron inner core, creates the magnetic field.
   B. Lodestones are magnetite—a mineral made primarily of iron. They can attract or repel other lodestones, like magnets. They can attract things made from iron. They can act like magnets.
   C. Not every lodestone is a magnet. Only magnetite which is struck by lightning becomes a lodestone—a magnet. The electric current aligns all the iron particles within the magnetite in the same direction. The particles are aligned along the direction of the earth's magnetic field. With all the iron particles aligned in the same direction, the magnetite becomes a magnet with north and south poles.
   D. A lodestone can be used to find north without looking at the sun or using a compass.
      1. Suspend a lodestone freely from a string or float it on a piece of light balsa wood in a bucket of water.
      2. Twirl the lodestone. It will align itself with the earth's magnetic field—one end will point North, the other will point South.
      3. Now have students confirm that the lodestone indeed aligns itself with the earth's magnetic axis by using a compass. Mark the "N or north seeking pole" of the lodestone.
   E. The liquid outer core of the earth moves, slowly, through the years, and this makes the earth's magnetic poles wander. It has even wandered to Antartica many times in the last 3 billion years. The last time the poles reversed was 780 million years ago.
   F. Declination measures the difference between magnetic north and geographic north. It is different at each location of the earth. It changes from year to year.
      1. National Oceanic and Atmospheric Administration keeps a record of declination value by year.

2. http://www.ngdc.noaa.gov/geomag-web/

G. The farther the treasure is from the starting point, the more that declination will affect the search.
H. Each location on earth can be defined in terms of latitude and longitude.

III. Skills
A. Map making
B. Understanding declination
C. Understanding expressing a location using longitude and latitude.
D. Finding longitude and latitude using a telephone app.
E. Adjusting bearings on a compass and on a map to account for earth's declination.

IV. Materials needed
A. Magnetic Magic
B. Compass with declination adjustment
C. Lodestone
D. Bar magnet
E. Nails
F. Chalk
G. 12" ruler
H. 36" ruler
I. Student protractors for activity 2
J. Large Protractor for activity 3
K. Map of Squaretown (provided in this website, below this activity)
L. 3 rolls of sturdy twine about 300 feet long.
M. 2 Lengths of twine for suspending lodestone
N. http://www.ngdc.noaa.gov/geomag-web/
O. http://mynasadata.larc.nasa.gov/latitudelongitude-finder/

V. Activity 1 - confirm that a lodestone points to magnetic north.
A. Test the lodestone with some nails to show that lodestones are magnetic
B. Test the lodestone with the bar magnet to determine and mark its north pole
C. Suspend the lodestone, using the length of twine, from a high place in your classroom. Let it settle into position.
D. Verify by using a compass that the lodestone points along the earth's north-south magnet

VI. Activity 2 - See the effect of declination on a point on the map
A. Group students into groups of two.
B. Distribute the maps of Squaretown.
C. Discuss with the students the attributes of the map. Note that streets are laid out along north/south and east/west axis. Show students the different landmarks on the map, the elementary school, the ball field, the library, the pool.
D. Discuss with students how to find bearings on the map you've handed out.
1. On most maps, students would need to use parallel rulers (rulers attached to each other on hinges that allow them to separate and remain parallel). One lines up along north-south axis on the compass rose, the second one to draw north-south axis at the location from which they would start.
2. On the map you have provided, streets are lined up along north-south and east-west axis (All towns in Utah are oriented in this manner. So is the city of Baltimore.)

3. To find bearings of a direction, students should place the straight edge of the protractor along the horizontal streets of the map and place the mark on the center of the straight edge on top of the starting point. They will read the bearings by counting the number of degrees east or west of the 90º mark.

E. Have students find the dot at the elementary school. This will be the starting point.
F. Note the coordinates of the dot, provided at the left side of the map.
G. Ask students to position the protractor with the dot as the starting point and mark a point 40º East of North and draw a line from the elementary school, through the mark and to the edge of the map. This is the direction a student would walk following a compass.
H. Discuss the use of scale on the map.
I. Ask students to mark a point along the line about 1000 feet away from the start point.
J. Determine the declination at the school using http://www.ngdc.noaa.gov/geomag-web/
K. Place another dot on the map using the declination. Move to the right from the compass bearing line if the declination is east (adding to the original bearing) or move to the left from the bearing line if the declination is west (subtracting from the original bearing)
    1. Sailors use the nemonic Dead Men Can't Vote Twice **A**t **E**lections to determine whether to add or subtract the declination. If the declination is east, add. If the declination is west, subtract.
L. Draw the second line. This is the true or geographic bearing (adjusted for declination)
M. Using the scale, find a point along that line 1000 feet from the start point.
N. Consider with the students whether they would have been able to find an object placed at a true or geographic location by following the compass bearing.

VII. Activity 3 —See the effect of declination over the years in school playground.
A. Find the school's coordinates on http://mynasadata.larc.nasa.gov/latitudelongitude-finder/
B. Prior to the activity, cut three equal lengths of heavy twine. ideally the lengths of twine would reach from a place close to the school's outer walls to the edge of the playground.
C. Draw a line or secure a 36" ruler on the ground near to the school's outer wall and roughly parallel to it.
D. Drive a stake in the ground on the playground next to the line, on the wall side of the line or ruler and roughly in the middle of the line or ruler.
E. Tie the three lengths of twine to the stake so that each can rotate independently.
F. Have a student walk one of the lines, on an angle, to the opposite end of the playground and hold the line tight.
G. Place the midpoint of the straight edge of a large protractor by the stake and align it along the ruler and determine the bearing of the first twine.
H. Have another student determine the declination at your position using http://www.ngdc.noaa.gov/geomag-web/.
I. Have a second student take the second length of twine as far as it will go and hold it tight. Using the protractor, have the remaining students direct the student holding the line to move right or left to reflect the declination.
J. Have another student determine the declination at your position 100 years before current date using http://www.ngdc.noaa.gov/geomag-web/.
K. Have a third student take the third length of twine as far as it will go. Have the student move right or left to reflect the declination from 100 years ago.
L. Discuss with the students whether they would be able to find the treasure if they were within the school yard (possibly).
M. Now discuss what the lines would do if the distance from the starting point was longer.

VIII. Cross-curricular tie in

A. If a lodestone can become a magnet by being struck by lightning, what can we say about a piece of iron passed through an electric current?
   1. Can create a magnet by passing iron through an electric current
   2. Can create electricity by moving a magnet through a coil of wire
   3. This electricity is the basis of motors.

B. The Age of Discovery
   1. During the Age of Exploration or the Age of Discovery, explorers were trying to find what else was there.
   2. They were also trying to find different trade routes to bring spices and silk to Europe.
   3. The land routes to obtain spices and silk (India and China) had been closed or were dangerous.
   4. Governments funded voyages of discovery to see if they could find sea routes.
   5. Much of the exploration was down the African coast and around the Cape of Good Hope. Ships didn't have to lose sight of land to make these voyages. Perfection of the compass made travel in the open sea like Columbus' trip and later Portuguese explorers, which landed in Brazil, possible.
   6. Columbus and later explorers hoped to get to India and China by sailing in the other direction. The Americas got in their way.
   7. Discuss what would happen on an open sea voyage in a sail schooner without a compass. How would they find their way? In fact, would captains have ventured away from the sight of land without a compass?
   8. Consider kings and queens who funded these trips. Was it better to risk finding a new route in uncharted territory or keeping the same old unsafe ones?
      a) Consider why a king might give someone like Columbus money to try to find a western route.
         (1) Much less expensive to fund a few ships than to fund a whole army to fight the robbers on the road east.