Principles of Navigation

This project is important to science students because it implements a new technology with an age-old problem of navigation. Students are able to relate history, mathematics, science, and technology in an effort to determine their location on the earth and solve a challenging navigational problem as individuals and as members of a team. The project can be easily modified for the grade level or the time period involved.

12
GRADE LEVEL

ARTS
LANGUAGE
MATH
MISCELLANEOUS
SCIENCE
HISTORY
SOCIAL STUDIES

20
WEEKS

$1000
TOTAL BUDGET

Curriculum/State Standard

N.Y. State Science Standards
1, analysis, inquiry, and design,
2, use of information technology,
6, common themes of math, science, and technology, and
7, interdisciplinary problem solving, are met.

Overview

Students are introduced to the history and instruments of navigation and cartography. Next they are exposed to the physical principles of navigational equipment and the use of that equipment. Lastly, the students are asked to solve challenging navigational problems using mathematics, scientific principles, and technology.

Objectives

- The student will be able to identify and use simple and technologically advanced navigational instruments.
- The student will be able to interpret various types of maps and charts.
- The student will be able to explain the scientific principles of modern-day navigation.
- The student will be able to determine the location of a specified object.
- The student will be able to solve a challenging navigational problem.

Materials

Topographic maps, aerial photographs, star charts, navigational compasses, lens stereoscopes, global positioning systems (GPS units), PC interface cable, and topographic software.

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SHOPA Foundation for Educational Excellence
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THIS WINNING LESSON PLAN WAS SUBMITTED BY:

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"Principles of Navigation" project continued...

Readiness Activity

An activity to prepare the students for this unit is to obtain topographic maps of your area and have them try to locate their position on the map. The use of landmarks, man-made structures, streets, and map coordinates are all acceptable methods. Once they all have the location, ask them to write how they arrived at their answer. Compare the class results.

Strategies/Activities

A short history of navigation involving the explorers such as Marco Polo, the Vikings, and the Dutch serves as an introduction to the unit. How did they find their way to places and back again? There is a lot of information in the library and on the Internet.

A review of metric measurements may be appropriate at this time and/or conversions to English units.

Early methods of navigation are explored i.e. obtaining direction from the sun, latitude from the stars, using distinctive landmarks, and compass development. Triangulation is demonstrated as a method for determining location. Using the known distances from three fixed points, a location can be determined by the intersection of the three arcs.

Reading and creating maps, starting with simple road maps, aerial photographs, and topographic maps. Interpreting maps and trying to duplicate them is the objective of this segment. The use of the Universal Transverse Mercator Coordinate System is studied as well as the Public Land Survey.

Relating the scientific principles to modern navigation through the use of mathematics, physics, and technology is the focus of the next segment. Students are involved in various laboratory activities as described below.

a. determining direction from various sources such as the sun, the stars, and compasses ~ Most students know the sun rises in the East and sets in the West, but many will need help in locating the North Star and determining which end of the compass points North. Use the star charts and compasses to demonstrate.

b. distance equals rate of speed times the time traveled ~ There are several ways to demonstrate this principle; for instance, rolling a soccer ball on a smooth, hard surface and timing it at uniform distances (like every 5 meters). My students line up with stop watches and start them simultaneously when the ball is released. As the ball passes them, they stop their watches and record the time. We then graph the data by hand on graph paper and also with Excel.

c. distance traveled versus displacement and vector addition ~ Students are asked to walk a certain distance in a given direction, change direction, and walk another distance, and again change direction and walk another specified distance. Students must then calculate the total distance traveled and their displacement from the point of origin and determine the two are not the same.

d. determining latitude using a protractor and the North Star ~ Sight along the base of an inverted protractor to the North Star. By hanging a plumb bob from the center of the protractor, the angle of elevation above the horizon can be determined by equal but opposite angles. This angle is your latitude.

e. determining longitude using the prime meridian and a clock ~ By definition, the time the sun crosses the prime meridian is noon. Knowing what the time difference is between your position and the prime meridian can determine your longitude. Each hour represents 15 degrees of the complete circle of 360 degrees around the earth.

f. making a compass from a needle and cork ~ All ferro-magnetic substances like iron, nickel, or cobalt will point in a north-south direction if allowed to rotate freely. Attach a needle to a cork in such a manner as to allow it to float on water and rotate freely. The needle will align itself with the earth's magnetic field. To determine which way is north, observe the sun rising in the east or setting in the west, as you face east, north is on your left.

g. Exploring the earth's magnetic field and compass declination ~ Align a compass with north on a topographic map. The degree difference between magnetic north and true north is noted on the map in degrees. A 14 degree west declination means you must adjust your compass 14 degrees west of north to head in a true northerly direction. (Otherwise if heading north in the Eastern United States, you would end up in Greenland instead of the North Pole.)

h. Creating a map ~ Students will study the landmarks, topography, latitude, and longitude of an area and attempt to construct an accurate representation of the area on large construction paper.

“Principles of Navigation” project continued...

i. Mapping using a motion detector -- If you have a motion detector and the appropriate software for your PC, build some "topography" in your classroom by using chairs, desks, books, and boxes. Hold the motion detector at a constant height over the landscape you have created, and slowly walk along. The distance to each object will appear on the computer screen with fairly good accuracy. This is a simple representation of how satellite mapping is done.

j. Headings and bearings -- Using the topographic maps and the compasses, determine where you are on the map and where you want to go. With your compass adjusted for declination, you can determine the direction and the number of degrees from North you must travel in order to reach your destination

k. Introduction to global positioning systems -- There are many resource books on the history and principles involved in GPS. The users manual for most units also provides background information as well as operational information.

l. Setting a course to a known objective -- The above compass exercise can be repeated using the GPS units in place of the compasses. Most units have some built in topography, so you can determine where you are in relation to where you started. Some have electronic compasses built in as well.

m. Locating an object using compasses and GPS -- Have students locate an object using a compass heading and the topographic maps. Repeat the exercise with the GPS unit and a different object or landmark.

n. Limitations of compasses and GPS units -- Most GPS units are not as accurate as the compass. This limitation may become evident in the previous exercise. Batteries are also required for GPS units, a consideration for long navigational excursions. Compasses point to magnetic North not true North.

o. Calculating the elevation of an object -- The height of a building or landmark can be determined by several methods. 1) Measure the shadow of a building and compare it to the shadow of a meter stick at the same time. By proportions, the height of the building can be determined. 2) Using the same equipment for determining latitude from the North Star, sight along the top of the tree, landmark, etc., from a known horizontal distance. The angle of sight is measured from the protractor. Knowing the horizontal distance, and the angle of sight, the height can be determined.

p. Finding a hidden treasure -- The culminating group activity.

q. Navigating an unknown course -- The culminating individual activity.

Extensions of the program can be made into radar, sonar, and space navigation if there is time and interest.

Culminating Activity

Finding a hidden "treasure" and navigating an unknown course for a prize are the two culminating activities done as a group and as an individual. Groups of students try to locate a "treasure" at a given latitude and longitude using compasses or GPS units and their knowledge of navigation. Individuals try to follow a predetermined course and arrive at the destination closest to the time it takes to travel it at an average walking speed.

Evaluation

Students are evaluated by quizzes, exams, laboratory exercises, and their ability to find objects and navigate the course.