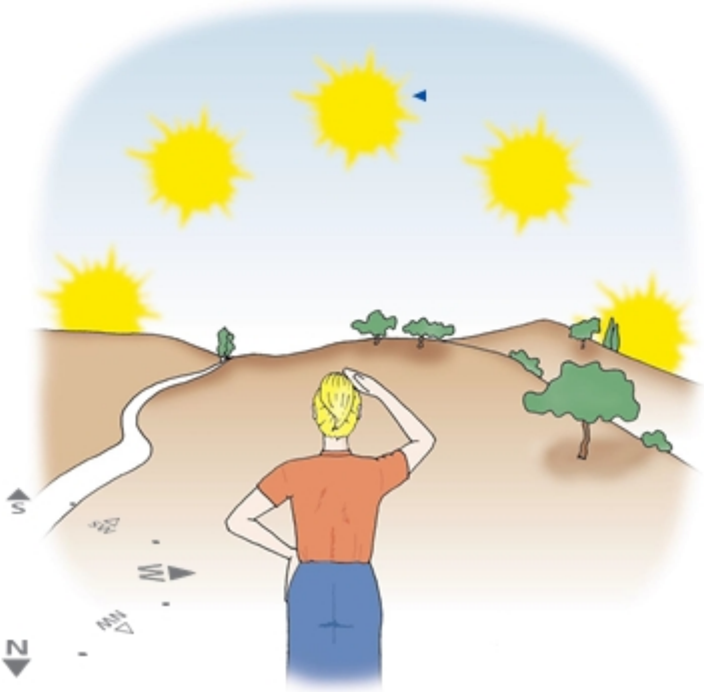
ASTROEDU

Peer-reviewed Astronomy Education Activities

How To Travel on Earth Without Getting Lost

Using a globe to learn how a position on Earth can be described.

Space Awareness, Leiden Observatory



AGE

8 - 14

LEVEL

Primary, Middle School

TIME

1h

GROUP

Group

SUPERVISED

No

COST PER STUDENT

Low Cost

LOCATION

Small Indoor Setting (e.g. classroom)

CONTENT AREA FOCUS

Astronomy, Earth Science

ASTRONOMY CATEGORIES

Astronomical instrumentation, Astrometry and celestial mechanics, The Sun, Stars

EARTH SCIENCE KEYWORDS

Geography

CORE SKILLS

Developing and using models, Analysing and interpreting data, Using mathematics and computational thinking

TYPE(S) OF LEARNING ACTIVITY

Structured-inquiry learning

KEYWORDS

Latitude, Longitude, Geography, Navigation, Maps, GPS, Earth

GOALS

With this activity, students learn the basics of geography and how to describe a position on Earth. For this purpose, basic vocabulary is needed like latitude, longitude, meridian, poles. The pupils learn to use tools like a compass to find their latitude using the stars. Mathematical skills like reading and measuring angles are reinforced.

LEARNING OBJECTIVES

- Students will be able to explain that the Earth is a globe, although maps are flat.
- They will be able to describe what latitude and longitude are and why they are useful.
- Students will be able to identify their position on the globe and to calculate their latitude and longitude.
- Students will be able to use the position of the stars to identify their latitude on the globe.
- Students will be able to explain why the Sun is sometimes to the North and other times to the South in Cape Verde.

EVALUATION

- Ask students to demonstrate how to find the latitude and longitude of their location using the materials given.
- Ask students in small groups to give the locations of different cities in terms of longitude and latitude.
- Ask students to draw the location of the Sun in the sky (with compass bearings) and a person with their shadow at midday in summer and in winter in Cape Verde.

MATERIALS

Items needed per group:

- Globe with lines of longitudes and latitudes marked
- Lamp
- Protractor
- Pencils x3
- Sticker
- Internet access to check the precise latitude and longitude coordinate of a location, use the following website: http://www.findlatitudeandlongitude.com/
- Download night sky app for tablet or mobile device e.g. Sky map or Pocket universe https://itunes.apple.com/us/app/pocket-universe-virtual-sky/id306916838?mt=8

Optional:

- string to wrap around globe
- compass to show north
- quadrant

BACKGROUND INFORMATION

The North Star
If we look at the sky at regular intervals during the night, we see that the stars move slowly around the North Star. In the Southern Hemisphere, all the stars move around a very dark area called the Coalsack. Nowadays, the North Star always shows the direction of true north and is only visible in the Northern Hemisphere. The Coalsack shows the direction of south and is only visible in the Southern Hemisphere.

Constellations are patterns of stars which form imaginary figures and which always seem to be in the same position relative to each other. The North Star is one of the tail stars of the Little Dipper constellation. You can see the Big Dipper, Cassiopeia and the Little Dipper, among others, in the sky. If you watch the night sky from a dark spot, you will see them easily. The most difficult one to find is the Little Dipper because the light of its stars is weaker. Start by finding the Big Dipper and Cassiopeia. Then try to find the Little Dipper by using the position of the three constellations as seen in the diagram. If you look at these constellations again an hour later, you will see that they have revolved around the North Star.

Where is the Sun

By looking at the horizon and knowing the direction of sunrise and sunset, we can tell in which direction we are moving. To turn back, you simply turn around and go back in the opposite direction.

This is easy when we are on land. We only need to take a fix on one or two points on the horizon and go the opposite way, changing the reference points on the right to the left and the points on the left to the right. Of course, if you have a compass you can tell which direction is north, which is south and where the other cardinal points lie. But it is also possible to find your way without a compass, because for instance, in Portugal the midday sun is always in the south.

The position of the Sun throughout the day

Sunrise in the East — Sunset in the West

The position of the Sun in the Northern hemisphere above the Tropic of Cancer

Finding our way at night, in the desert, or at sea is more difficult as we cannot see any reference points on the horizon. In the Northern Hemisphere, the North Star is always in the north and is visible at night. So if we turn to the North Star, the Sun will always rise on our right and set on our left. If you live in Cape Verde, which lies between the Tropic of Cancer and the Equator, you can still see the North Star in the north. But, depending on the season, the midday sun may be north or south of your position. If we travel to the Earth's Southern Hemisphere like Portuguese navigators from the 15th century on, we can no longer see the North Star. But the Coalsack will always show us the way south.

Note that there are different ways to find the North and South poles. For instance, in the Northern Hemisphere finding Cassiopeia is important but not necessary. See: http://apod.nasa.gov/apod/ap070108.html
In the Southern Hemisphere: there are at least different 4 different methods of finding the south pole, see: https://en.wikipedia.org/wiki/Celestial_pole#Finding_the_south_celestial_pole

Some instruments for navigation

A quadrant is an instrument developed by Ptolemy and later improved by medieval Muslim astronomers. Navigators used it to measure their latitude. They would look at a star through the sights and hold the quadrant until the plane was vertical. The altitude of the North Star as measured with a quadrant corresponds to your latitude if you are in the Northern Hemisphere. Navigators would also use the instrument with the altitude of the centre of the sun, and by looking in front of them with the sun on their side to avoid having to stare at it.

Latitude

By observing the Sun, and the regularity of the Earth's rotation around the Sun, astronomers and geographers were able to find practical ways to determine our position on Earth.

Locations to the north and south of the Equator were marked along circular parallel lines drawn around the Earth. These lines are called the parallels and their positions are measured in degrees: the Equator is the Zero Degree line, the North Pole is at a 90º N angle to the Equator and the South Pole lies at a 90º S angle to the Equator. The measurement of the north- south position is called latitude.

To determine the latitude of a location during the day, in addition to knowing the angle of the midday sun above the horizon, the date, your approximate position on Earth, you also need to know if you are in the Northern or Southern Hemisphere and your position relative to the tropics. In the Northern Hemisphere the angle of the North Star above the horizon is the latitude of your location.

The latitude of a location is the measurement of the angle if you travel from the Equator to the parallel which passes through this location, perpendicular to the

Equator. At any time of night, this angle is equal to the angle of the North Star above the horizon. Measuring latitude is easy, because in the Northern Hemisphere, the North Star is always visible in the night sky.

Longitude

Latitude only gives information about one part of the location on a globe. To give full information about the location of a place, we need to use a second reference showing where the horizontal location on the globe is.

Meridians or longitude lines link the North and the South poles on the globe, like the segments of a satsuma. Each meridian crosses the equator line. As the equator is a circle, we can divide it in 360°. For historical reasons and since 1884, the count starts with the line crossing the Royal Observatory of Greenwich, in London, UK. This is known as the prime meridian, where the longitude is defined as 0°. . Moving east of the Prime Meridian, the longitude is measured in degrees east up to 180°, e.g. Paris has longitude 2.4°E. Similarly moving west, longitude is measured in degrees west, e.g. Lisbon has longitude 9.1°W.

If we know the latitude and the longitude of a place, we can localize it on the globe. It is called the coordinate.

Units of longitude and latitude

Both longitude and latitude are measured in degrees. For a more specific location, fractions of a degree can be used. Alternatively, in a similar way to hours, degrees can also be subdivided into arcminutes (‘) and arcseconds (“), with 60’ in a degree and 60” in an arcminute. So the tilt of the Earth, 23°30’ is equal to 23.5°. This exercise uses fractions of a degree.

FULL ACTIVITY DESCRIPTION

Activity 1: Our position on Earth: latitude

Step 1:

Students find their city on the globe. Use the app which shows you the view of the night sky on an iPad or mobile phone based on your location. The app can do this based on your location or you can type in your location (or the location of your nearest city).

Step 2:

If there is one device for the class, ask for a volunteer to locate the North Star if you are in the Northern hemisphere or the Coalsack if you are in the Southern hemisphere.

Step 3:

The student rotates and moves the device around until they find the North Star or Coalsack. Use the compass included on the app or another student can use a compass to find North or South as appropriate. Ways to locate these objects are included in the background information.

Step 4:

Once they have located the object ask them to keep pointing the device in the same direction.

Step 5:

Ask for a second student to measure the angle of the North Star or Coalsack above the floor/ horizon with a protractor. Alternatively if you have a quadrant, the night sky view can be presented on a vertical screen and students look through a quadrant to measure the angle of the object above the horizon. This activity could also use a quadrant to look at the real night sky on a clear night.

Step 6:

Students note the angle they found. (This angle is the latitude of the place you are in).

Step 7:

Ask students if everyone sees the North star (or Coalsack) at the same angle? Why/why not? Try inputting different locations around the world in both hemispheres and measuring the angles of the north star (or coalsack if you saw this in your location) above the horizon or noting if you cannot see it. Point out where they are on the globe to compare. Come to the conclusion that people in the Northern hemisphere can see the north star (and people in the southern hemisphere cannot) but see it at different angles depending on their location (or equivalent with the Southern hemisphere and the coalsack). Explain that this angle tells us how North or South we are. This is called our latitude. Write this word on the board.

Step 8:

Show students the lines of latitude on the globe. Have they heard of the equator and do they know where it is? Show them and explain that the equator goes around the middle of the Earth. We label the equator 0°. If we travel north, the angle increases until we reach the North Pole which is at 90°N, and travelling south from the equator, the angle increases to the South Pole at 90°S.

Step 9:

Ask students how we could use this information. Come to the conclusion that we could measure the angle of the North star/ Coalsack to find our latitude and help find our location on Earth, as explorers travelling by sea did.

Activity 2: Our position on Earth: longitude

Step 1:

Ask students if knowing how North or South we are is enough to pinpoint our exact position on Earth. The answer is no. Even knowing how North or South we are, we could still be anywhere along the same parallel line, e.g. Nice in France and Toronto in Canada are both at a latitude of 43.7° but are very far away from each other.

Step 2:

Ask students to say/ point out the location of the two different cities on the globe. Ask students if they can think of another piece of information they could use to distinguish the two cities: how are they different?

Step 3:

Come to the conclusion the horizontal position on the globe, i.e. the East-West location are what separates them. Explain we divide the globe using lines from the North to the South pole, like the segments of a satsuma. Ask students to point out the lines on the globe. Explain we call these lines of longitude and write this word on the board.

Step 4:

Ask students to imagine getting on a plane and flying in a plane travelling East. The plane would travel in a circle. Ask students how many degrees there are in a circle. Answer: 360°.

Step 5:

Ask students if there is anywhere obvious to start counting the lines of longitude from? No, there isn't as the Earth is a sphere. Explain that in 1884 it was agreed that the line passing through London would be the Prime Meridian with a longitude of 0°. Moving East, the angle increases up to 90°E and then 180°. Moving west from the prime meridian, the angle increases up to 90°W and then up to 180°.

Step 6:

Students use the globe or a world map to find the longitude of their location. They note the result. Students can now give the full coordinates, longitude and latitude, of their location.

Step 7:

Ask students if they know of a way to find your location more precisely than using a globe. Can we use technology? How can you navigate in a car?

Step 8:

Explain that today, we are able to give much more precise coordinates for a location using the Global Positioning System (GPS). This is a network of satellites orbiting the Earth in space used for navigation. If a GPS receiver can 'see', i.e. communicate, with four or more of these satellites, its location can be found by using a triangulation technique.

Activity 3: Direction of the Sun

Cape Verde is just off the west coast of northern Africa with a latitude of 15°N, placing it between the equator (0°) and the Tropic of Cancer (23.5°N). Using this knowledge, we investigate why the inhabitants of Cape Verde sometimes see the midday sun in the north and at other times in the south.

Step 1:

Make sure students can all see the globe. Ask students to find their location, the Equator and the north-south axis on the globe. Could wrap a piece of string around globe to show location of the equator.

Step 2:

Light up the globe with a lamp and tilt the axis slightly towards the light so that the area around the North Pole, outlined by the Arctic Circle, is lit up. Place a pencil against the globe and move it vertically between the North and South poles on the globe. Show that if you move the pencil to the north, its shadow will point north and the Sun will be to the south. If you move the pencil towards the south, its shadow will point south because the midday sun is to the north.

Step 3:

Ask students what they observe. Moving northwards, ask which direction is the shadow pointing in if the pencil is above the Sun? (To the south). Moving southwards, ask which direction is the shadow pointing in if the pencil is below the Sun? (To the North). They should also be able to see that there is a point where the pencil casts no shadow.

Step 4:

Tell students there is a circle of latitude, like the equator but it does not go around the middle of the Earth. It is called the ‘Tropic of Cancer’ and is at 23.5º north of the equator. Can they use what they learnt earlier to work out where this is? Place the pencil against it at this latitude.

Step 5:

Tilt the axis so that there is no shadow when the pencil is on the Tropic of Cancer. The axis of the globe is now inclined 23.5º relative to the vertical. For anyone standing on the surface of the Earth at the point where the pencil meets the globe and who can see the Sun in the position of the lamp, it is midday on June 21st.

Step 6:

Tell students the latitude of Cape Verde is 15°N. Can they work out where this is on the globe? Is it north or south of the Tropic of Cancer? You may wish to place a sticker to indicate its location.

Step 7:

Keeping the same tilt as above (so the Sun is directly above the Tropic of Cancer), move the pencil to the location of Cape Verde. Ask students in which direction the shadow is pointing (should be to the south).

Step 8:

Now move the Earth/ globe so that is on the opposite side of the Sun/ lamp to represent six months later. The north axis should now be pointing away from the Sun at the same angle so the South pole is lit. Ensure that Cape Verde is pointing towards the Sun. Ask students over which part of the Earth is the Sun directly over and demonstrate as before with the shadow of the pencil. (The Sun is directly over the Tropic of Capricorn which is 23.5ºS).

Step 9:

Place the pencil on Cape Verde. Ask students what they notice about the direction of the shadow. (It is now pointing to the North).

Step 10:

So people in Cape Verde sometimes have midday shadows to the North or the South depending on the time of year because the direction of the midday sun changes during the year. In fact, all people who can see the midday sun to the north or south at different times of the year live between the Tropic of Cancer and the Tropic of Capricorn.

Step 11:

The answer to our question is simple. As the north-south axis of the Earth is inclined relative to the plane of the Earth's orbit, the midday sun on the first day of summer south of the Tropic of Cancer will be in the north. But in the autumn, between the Equator and the Tropic of Cancer, the midday sun will be in the south.

CURRICULUM

Country	Level	Subject	Exam board	Section
UK	KS2	Geography	-	Locational knowledge: identify the position and significance of latitude, longitude, Equator, Northern Hemisphere, Southern Hemisphere, the Tropics of Cancer and Capricorn, Arctic and Antarctic Circle, the Prime/Greenwich Meridian and time zones (including day and night).
UK	KS3	Geography	-	Geographical skills and fieldwork: build on their knowledge of globes, maps and atlases and apply and develop this knowledge routinely in the classroom and in the field.
UK	KS2: Year 5	Science	-	Earth and Space: use the idea of the Earth's rotation to explain day and night and the apparent movement of the sun across the sky.
UK	KS2: Year 5	Maths	-	Geometry- properties of shapes: draw given angles, and measure them in degrees (o).
UK	KS3	Maths	-	Geometry and measures: draw and measure line segments and angles in geometric figures, including interpreting scale drawing.

ADDITIONAL INFORMATION

CONCLUSION

With this activity, students learn that the Earth is a globe and that we can define a position on the globe by using latitude and longitude. After implementation, students are able to determine the latitude of a place on Earth using a compass, the night sky and a protractor. Students can find their location on a globe and describe it in terms of longitude and latitude. Students learn why in Cape Verde, the direction of the midday sun changes over the year.

CITATION

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