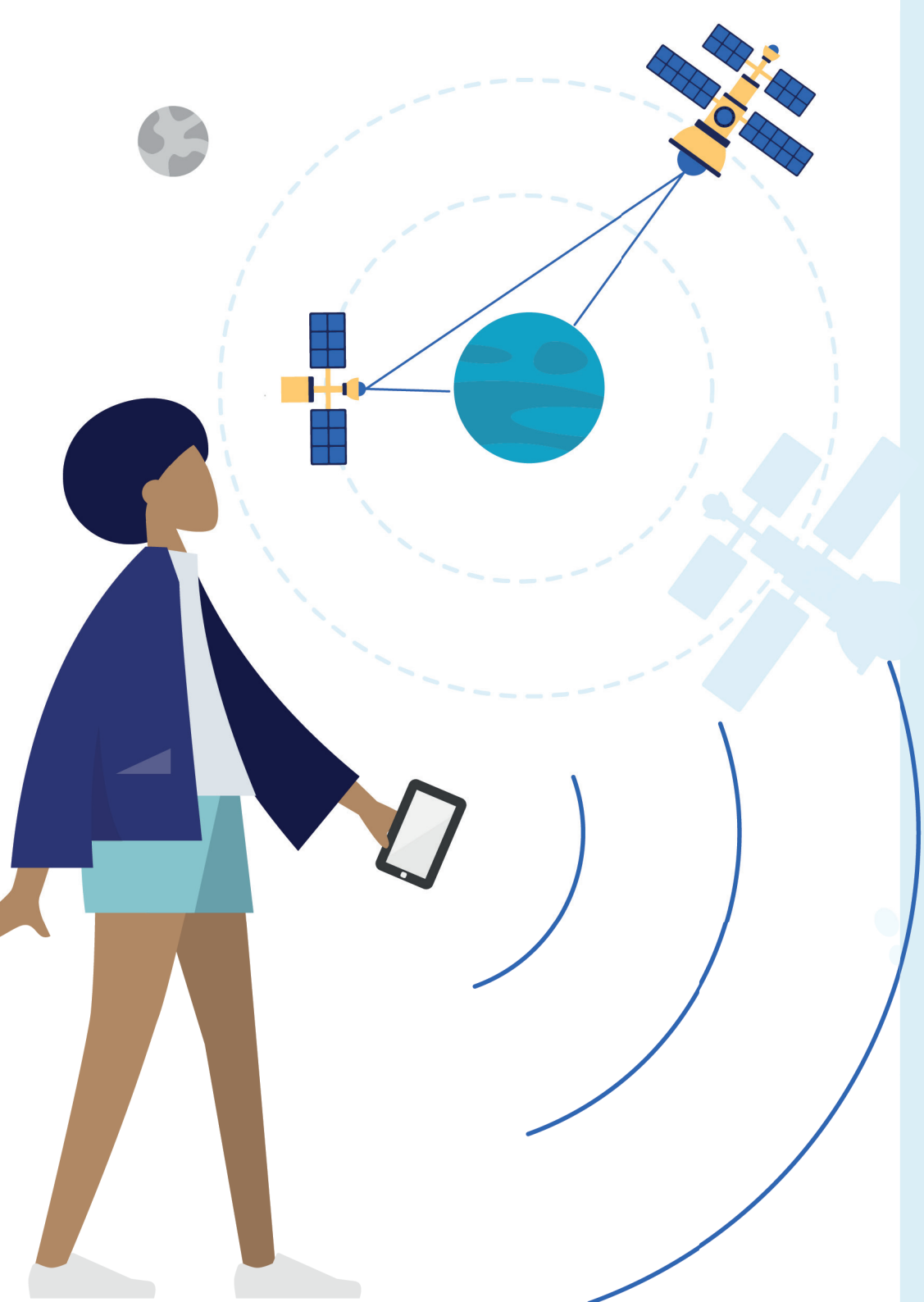

PRIMARY + STEM

Teaching Resource

ACTIVITY: GPS

ACTIVITY OVERVIEW

Satellite navigation is based on a global network of satellites that transmit radio signals from space. There are several systems put in place by different countries, i.e. Russia (GLONASS), China (BeiDou), and European Union (Galileo). The one that most people are familiar with is the Global Positioning System (GPS) technology that is developed and operated by the United States. There are innumerable and ever-growing applications for this technology in all areas of life, research, health, and commerce.

Students explore the use of this technology in looking for a missing pet and in studying the imaginary migratory path of a bird across the world. In the process, they learn about latitude, longitude, and take a sneak peek into wondrous sights that are made available through amazing virtual tours.

SYNOPSIS

Satellite navigation is based on a global network of satellites that transmit radio signals from space. There are several systems put in place by different countries, i.e. Russia (GLONASS), China (BeiDou), and European Union (Galileo). The one that most people are familiar with is the Global Positioning System (GPS) technology that is developed and operated by the United States. There are innumerable and ever-growing applications for this technology in all areas of life, research, health, and commerce.

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Foundation – Year 2

- Identify and explore digital systems (hardware and software components) for a purpose (VCDTDS013)
- Follow, describe and represent a sequence of steps and decisions (algorithms) needed to solve simple problems (VCDTCD017)

Years 3 – 4

- Explore a range of digital systems with peripheral devices for different purposes, and transmit different types of data (VCDTDS019)
- Explain how student-developed solutions and existing information systems meet common personal, school or community needs (VCDTCD025)

Year 5 - 6

- Examine the main components of common digital systems, and how such digital systems may connect together to form networks to transmit data (VCDTDS026)
- Explain how student-developed solutions and existing information systems meet current and future community and sustainability needs (VCDTCD034)

ACTIVITY, MATERIALS AND INSTRUCTIONS

Activity

The ways that GPS technology can be used in all areas of life, research, health, and commerce continue to grow.

Using an imaginary GPS tracker and Google Maps, students go in search of their pet dog .

Materials

- Worksheets (Foundation to Year 2; Years 3 to 6)
- Pen or pencil
- Computer or similar device
- Internet
- Google Maps

Instructions

1. Discuss how a satellite navigation technology like a GPS works to help us find our location. Global positioning system (GPS) is made up of three parts: satellites, ground stations, and receivers.

   A) GPS satellites orbit Earth once a day, 365 days a year. They send out radio signals all the time, not unlike the radio signals we receive from our favourite radio stations.

   B) The ground stations check on how accurate satellites are, check on their health, and monitor their movements. There are ground stations on every continent in the world.

   C) A receiver in our phones or cars is a one-way communication device that constantly listens for a signal from the satellites. The receiver calculates out how far away it is from each of the satellites and then figures out its location in latitude and longitude coordinates.

   This system does not require internet access because it gets its position information directly from the satellites overhead. This means that, even without the internet, our device is still able to locate itself in coordinates. However, we won't know where it is on a map, unless there is already a previously downloaded map in our device.

   When there is internet access, we are able to use navigation apps like Google Maps, and get information like traffic updates and road closures.

2. Students work in groups of two or three. Issue each group a worksheet.

3. Open Google Maps on computers or devices.

4. Input the coordinates in the search box.

5. These coordinates can be found in the worksheets.

6. Discuss.

   Where are these locations?

   What are some other uses of technologies like GPS?

   Under what circumstances would GPS not be accurate?

HOW TO USE THIS ACTIVITY WITH YOUR STUDENTS

Foundation - Year 2

GPS data gives us the locations that the pet dog had visited. What it doesn't do is to tell us the adventures the dog has had.

Students write or illustrate an adventure they imagine that the pet dog had (e.g. making friends with a friendly lion at the Werribee Zoo).

Years 3/4

Online platforms allow communities to access information they would otherwise not be able to. Students select one of the sites on the worksheet and visit a famous institution via virtual tours (e.g. museums, art galleries). For example, in Paris, they could visit the Louvre, while in London, they could visit the British Museum, National Gallery, etc.

Here are some possible sites for students to explore:

- Online tours (louvre.fr)
- Collection | British Museum
- Virtual tours | Visiting | National Gallery, London
- Triennial 2020: Virtual Tours | NGV
- Art Gallery of New South Wales, Sydney, Australia — Google Arts & Culture
- Australian Museum, Sydney, Australia — Google Arts & Culture

Discuss how these platforms serve the community at large and explain what needs are being met.

Years 5/6

Highlight the different digital systems required to use the GPS for locating people and places, such as devices (e.g. mobile phones or tablets), GPS receiver in the device, GPS satellites in the skies, internet access using a mobile phone network or Wi-Fi, camera, and apps like Google Maps.

Once students are familiar with the different digital systems in the activity, they could apply their learning through a live treasure hunt which uses GPS, Google Maps, and a classroom chat platform/email. The teacher hides two or three items on the school grounds, each item quite far away from the next one. The objective of this treasure hunt is for every group to find all items. Give the coordinates of ONE item to a group. Every group should get coordinates to a different item.

When students have found it, they take a photograph of the item, pin its location on Google Maps, and share the coordinate on a class chat. This will allow other groups to find the item. Can students come up with rules to make this game fun for themselves? E.g. they are not allowed to interact with one another outside of communicating via a common chat platform, or that they can only communicate the GPS coordinates.

DISCUSSION SECTION AND KEY THEMES

KEY THEMES

GPS

The Global Positioning System (GPS) that we have had access to since the 1980s is a space-based satellite navigation system that provides location and time information. The GPS technology is part of a larger network of satellites called the GNSS (Global Navigation Satellite System) which comprises satellites from other countries (e.g. Russia (GLONASS), EU (Galileo), Indian (IRNSS), and China (BeiDou)).

The GPS system that most of us are using is owned by the United States government and is made up of a network of about 30 satellites orbiting in space.

It can be freely accessed by any device that has a GPS receiver, such as laptops, mobile phones, cars, watches, and even dog collars!

Parts of a GPS system

Satellites

GPS satellites orbit Earth once a day, 365 days a year. Wherever we are, we are usually in sight of at least six of them, but we only need signals from three or four of them to determine our position. These satellites constantly send out radio signals, not unlike the radio signals we get from our favourite radio stations! These signals are neither AM nor FM. The signals are carried on a set of frequencies called the L-band. This allows the signals to be able to penetrate clouds and fog. These digital signals (patterns of 1s and 0s) carry information about what time they were sent and the position of the satellites when they were sent.

Ground control network

Equipment on the ground includes antennae, monitors, and control stations, to track and take command of the GPS satellites, as well as monitor their performance and health status.

GPS receivers

The GPS receivers in our devices (e.g. cars, mobile phones, tablets, Fitbits, etc.), have antennae that are programmed to receive signals from four satellites at any one time. A small microchip in the device then decodes the satellite signals and performs calculations, based on the GPS information. By knowing how long it takes the signals to reach the phone, the device can calculate how far away each of the satellites are. If our devices know how far away it is from four satellites, it can pinpoint our location. This method of determining location is referred to as 'trilateration'.

Timing is everything in determining location. Both GPS satellites and receivers must know exactly what time the signal was sent, so the distances between the GPS receiver and all four satellites can be calculated accurately. Every satellite is fitted with very stable and accurate atomic clocks, but even they need to be corrected. Left on their own, they would slow down by 10 nanoseconds a day. This may not sound like much but, since the radio signals they emit travel at the speed of light, even such a small error could lead to a GPS position error of three metres. This is not an acceptable error if there are going to be self-driving cars on the road.

This system does not require internet access because it gets its position information directly from the satellites overhead. This means that, even without the internet, a device with a GPS receiver is still able to locate itself in coordinates (latitude, longitude). However, we won't know where this position is on a map unless there is already a map in our device which was previously downloaded.

When there is internet access, we can use navigation apps, such as Google Maps, and get useful information, like traffic updates and road closures.

Latitude and longitude

Most GPS receivers are programmed to use latitude and longitude to locate their positions. Latitude and longitude are commonly referred to as geographical coordinates. They are part of the geographic coordinate system, which has been around since the time of the Greeks. This set of imaginary lines enables us to represent every location on Earth by a pair of numbers we call coordinates (e.g. Sydney is located at -33.8696°, 151.2070°). The first number refers to its latitude and the second to its longitude. Sometimes the coordinates are written using degrees, minutes, and seconds instead (e.g. Sydney 33°52′4.8″S, 151°12′36″E)

Latitudes tell us how far north or south a point is relative to the Equator. The Equator is an imaginary line that is equally distanced from both poles, and it divides Earth into the Northern and Southern hemispheres.

Latitudes are expressed in degrees between 0 to 90˚, and the Equator is designated 0˚ latitude. North of the Equator, values are positive, while south of the Equator, values are negative (e.g. London is 51.500N˚, while Melbourne is -37.814˚).

Longitude is the counterpart set of imaginary lines. Instead of the Equator, another reference line called the prime meridian separates the Eastern from the Western hemispheres. The prime meridian passes directly through Greenwich, England, and is also known as the Greenwich meridian (0˚). The longitude varies between 0˚ to 180˚. East of Greenwich, the values are positive, and west of Greenwich, the values are negative (e.g. Shanghai is 121.473˚E, while New York is -75.611˚E).

QUESTIONS AND ANSWERS

What is GPS?

The Global Positioning System (GPS) is a technology (there are other similar ones) made up of about 100 satellites orbiting in space. All of them emit radio signals from space. These signals can be received by any device that has a receiver (e.g. our laptops, mobile phones, cars, watches, and even dog collars!).

Our devices always receive signals from these satellites at any time of day or night, and these signals help us work out our location.

Why are there clocks on satellites?

Clocks are important because, by knowing how long it takes for a signal to travel from a satellite (in space) to a receiver (on Earth), the distance between them can be calculated accurately. If the receiver can calculate their distance from four of these satellites, the location can be pinpointed.

All clocks are unstable in nature and an inaccurate clock will lead to miscalculations in distances. Atomic clocks are the most stable but even they will produce inaccuracies over time. There is a lot of research being done to improve on these atomic clocks, including the work done at the University of Western Australia's Atomic Clock Lab.

New atomic clock is so accurate it would only be about 0.1 seconds off - in 14 billion years! - Study Finds

Is the GPS signal from satellites able to locate things that are indoors?

GPS satellites do not transmit strong enough signals to reach indoors, through roofs and walls of buildings. GPS signals that do enter buildings through windows bounce around the room a lot, making the calculations inaccurate.

How accurate is the GPS?

The accuracy of a GPS refers to how close the results can pinpoint to the actual position. This accuracy depends on a number of factors, including the number of satellites the GPS receiver is getting information from, how modern and accurate our GPS receivers are, signal interferences caused by buildings, proximity to tall structures, such as mountains, and disturbances in the atmosphere brought about by solar flares and extreme weather.

Current data shows that GPS can get as close as 15m to the actual position.

What are latitudes and longitudes?

If we can imagine a grid overlaid over the globe like netting, with imaginary lines that run across (latitude), and lines that run up and down (longitude), then we can give each location a unique set of numbers that correspond

to their position on this grid. GPS coordinates give the position of place by its latitude first, then its longitude (e.g. Sydney is located at -33.8696˚, 151.2070˚)

Why do latitudes and longitudes have negative numbers?

A number that is positive or negative tells us on which side of Earth it is. For latitudes, any location that is north of the Equator is given a positive value, while any location south of it is negative (e.g. London is 51.500N˚, while Melbourne is -37.814˚).

For longitude, any location that is east of the Prime Meridian (an imaginary line that goes through Greenwich, a town in London, England) is given a positive value, and any place to the west of it is given a negative value (e.g. Shanghai is 121.473˚E, while New York is -75.611˚E).

How do animals navigate without GPS?

It's amazing how animals can find their way around without maps or instruments! Animals like terns, monarch butterflies, and salmon migrate thousands of kilometres to and from the same breeding grounds. Bees know where flowers are in relation to their hive, and whales swim between hemispheres every year… and these are just a few examples.

Scientists have already discovered that some animals use the sun and stars to navigate, others use Earth's magnetic field, and others use what they see and learn key landmarks around them.

There is still a lot to learn about how different animals navigate. What is known already, though, is how human activity has affected some species' navigational skills adversely, with the impact of pesticides proven to interfere with bee navigation, and light pollution thought to harm turtle navigation.

How big are satellites?

Man-made satellites vary in size, from being about as big as a football field (International Space Station), to a school bus (Hubble Space Telescope), to something as small as a beach ball (Sputnik 1). However, over the last few years, satellites have become miniaturised. In 2017, the lightest one (Kalamsat) was only 64g and it was designed by a student!

Size of Famous Satellites (businessinsider.com)

Is it a good idea to use GPS tracking watches for kids?

In 2019, the Royal Children's Hospital in Melbourne surveyed parents about the use of tracking devices (e.g. watches and mobile phones), to monitor the location of their children when travelling independently. The poll results show that, while many parents feel comforted and reassured when they know their children are safe, many parents have raised concerns that using these devices has led to tensions in homes where children don't like feeling that they are being spied on. The jury is still out!

More parents using GPS to track children but experts warn there could be consequences - ABC News

Do we need the internet to use GPS?

This system does not require internet access because it gets its position information directly from the satellites overhead. This means that, even without the internet, a device with a GPS receiver is still able to locate itself in coordinates (latitude, longitude). However, we won't know where this position is on a map unless there is already a previously downloaded map in our device.

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OUTSIDE OR SUPPLEMENTARY READING

What is GPS?

- GPS | National Geographic Society
- Satellite Navigation - GPS - How It Works | Federal Aviation Administration (faa.gov)

Satellites in space

- How many satellites are operating in space? | World Economic Forum (weforum.org)

What are latitude and longitude?

- Geographic Coordinates: Latitude, Longitude & Elevation - Video & Lesson Transcript | Study.com

How to use coordinates on Google Map

- Discover coordinates or search by latitude & longitude - Computer - Google Maps Help

Virtual tours

- Australia's Best Virtual Tours, Zoo Cams & Museums to Explore From Home - Newy with Kids

TOPIC WORDS

- satellite
- navigation
- platform
- location
- latitude
- longitude
- mapping
- direction
- distance

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