Reading Crusade Teaching Resource on GPS

What is GPS?

GPS (Global Positioning System) is widely known as a system that tracks your location using the signals from satellites. GPS was originally developed and used by the US military for years, until in the 1980s when it became available for the public.

How do GPS acquire the location information? The GPS antenna (receiver) that is installed in car navigations, for example, receives a number of signals out of 25 GPS satellites (29 altogether, including 4 spare satellites) that orbit the earth at an altitude of 20,000km. The satellites orbit the earth twice a day in the speed of 7,000 km an hour to provide worldwide coverage. There are at least 4 satellites that are visible at all time from anywhere on earth. Each satellite transmits radio signals, at the speed of light, that indicate its position (the exact orbits of the satellites) and precise time to the GPS receiver. The radio signals reach the receiver at slightly different times because some satellites are farther away than others. By measuring how long it took for each satellite to reach the receiver, the receiver calculates its distance to each satellite. Once the distance is measured from at least 4 satellites, the receiver uses a simple mathematical principle called trilateration to identify its location. The satellites last about 7-8 years, so replacements are launched in the orbit almost every year.

Watch *"How Do Global Positioning Systems, or GPS, work?"*
http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/How_Do_Global_Positioning_Systems.html

Download *GPS Educational Poster*
http://www.gps.gov/multimedia/poster/

Is GPS accurate?

All GPS satellites have an atomic clock installed, which is very accurate. GPS receivers do not have an atomic clock installed since they are expensive. Instead, the receivers have a normal quartz clock installed, which resets all the time to synchronize with the atomic clock in the satellites. So in principle, the GPS receiver is as accurate as the satellites.

Common GPS receivers have accuracy up to 5-10 meters. Some GPS receivers use differential GPS (DGPS) that helps correct inaccuracies caused by radio signals traveling through the earth's atmosphere and bouncing off large objects like skyscrapers. Using DGPS allow more accurate tracking, up to approximately 2-5 meters.

GPS is used to study earthquakes and volcanoes as well. GPS can be used to measure the movement of earth, how far and in what direction the earth has moved. Scientists use this information to predict future changes and monitor the movement. GPS has a potential to make a quicker analysis on earthquakes,

compared to analysis done through seismometers, thus reducing the time to send emergency warnings.

GPS applications in everyday life

GPS is used for a variety of commercial applications. Here are some of the examples.

Car navigations: This is probably the most common application using GPS. With the integration of GPS and GIS (Geographic Information System), car navigations can pinpoint your exact location on the map, and shows the route and speed in which you are traveling. Some devices calculate routes to avoid traffic jams.

Smartphones: Many mobile phones and smartphones integrate GPS receivers. These days with the help of A-GPS (Assisted Global Positioning System), mobile phones can receive the location data much faster, up to 5-10 meters accuracy, or even in indoors (up to approx. 20 meters accuracy), or in non-optimal environment. In some countries, there are also GPS installed phones and shoes that are specifically targeted for young children and elderly. These phones are developed to ensure the safety of young children walking to schools on their own and protect the elderly from getting lost.

Digital Cameras: For people who go traveling often and take photos, it is quite convenient to use the GPS installed digital camera. Using built-in GPS digital camera allows you to record the location data of the photographs taken.

Watches: GPS integrated sports watch is commonly used for both athletes and non-athletes who play sports. GPS sports watch allows you to check the time, map, speed and heart rate. The data can be checked and saved in your computer afterwards.

Games: The modern treasure hunting called “geocaching” is the most popular location-based game in the world. There are approximately 5 million cache hunters across 150 countries. All you need for playing the game is a GPS receiver, such as smartphone. Anyone can either hide or find a cache, pretty much anywhere in the world.

GPS and sports

GPS not only tracks your location but also tracks the movement of a person. GPS is used in the field of Sports Science, for its research in professional sports, including rugby, football and American football. Canterbury Crusaders Rugby team uses the GPS technology, to optimize their trainings and performances. The players in the Canterbury Crusaders put the GPS device on their back during the game and trainings. The device tracks the data, including distance, speed, heart rate, impact & body load, and work rate markers, all in real time.

Live data allows coaching staff to act immediately on the information that is available. This may include adjusting a training drill to increase intensity or adding volume to achieve the desired load. Using GPS device can also reduce the risk of injuries by analyzing the impact of tackles on player's bodies. Data is available for up to 100 players in real time. Within minutes of downloading data from the devices, reports are available and ready to share with coaching, conditioning and medical staff.

One of the challenges for rugby players is to develop high levels of fitness elements, such as speed and agility, strength, and endurance, all in a good balance. Each position has different roles and different demands for the player. For example, the strength is more important for forwards and speed for backs.

Rugby players need to train themselves to reach the maximum speed in short time. It is quite different from the training method of sprinters who run relatively a long distance in a straight line. Since most rugby players only run a short distance, it is important for them to have excellent acceleration, outstanding balance and agility, and tremendous strength to avoid injuries. Speed training is different depending on the player's position. Forwards need to pick up the ball and dash right away, whereas, backs need to stop or cut opponents while running. Overall, it is important for the rugby players to train acceleration speed with agility since they need to change directions immediately without losing the pace.

It is also very important for rugby players to train their strengths. By training the strengths of muscles and joints, they can prevent injuries and increase power to play until the last quarter of the game.

Rugby players need an incredible amount of endurance, or stamina. Since the players, especially forwards experience collisions repeatedly, they need a lot of stamina to minimize the fatigue. Unlike the endurance required in sports like marathon, rugby players require stamina to last over 80 minutes of repetitive bursts.

Watch *"Crusaders Training – Player GPS Tracking"*
http://crusaders.onsport.co.nz/video/crusaders-training-player-gps-tracking/

Possible learning activity:

1) Become an engineer and understand the basic concept of GPS using triangulation method.

TeachEngineering digital library collection has a hands-on activity for students to learn the basic concept of GPS through a triangulation method. Students learn the basic mathematic principle integrated in GPS.

This activity allows the students to become "engineers" who will use the triangulation method to find a precise location of someone on a map. The

students will be divided into groups of 2-3, depending on the class size. Each group will have a box, map, ruler and scissors. Each group of students will choose a mystery location on the map that is placed inside the box. The students will then measure the distance from the secret location to the points of the three sides of the box. They will use the strings and a ruler to measure the distances. Once the mystery point and the measurements are determined, the groups will switch the boxes, and try to identify the mystery point using the measurement data.

After this activity students should be able to:

1. Describe a satellite and how it helps in locating a person on Earth.
2. Explain how triangulation is used to find a location.
3. Describe how engineers are involved in the design and use of satellites.
4. Use strings to measure distances between points.

The details of the activity is on the website:
http://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_rockets/cub_rockets_lesson06_activity1.xml

2) Geocaching

Combine an outdoor recreational activity with a treasure hunt using geocaching. Geocaching is a free application that only requires a GPS receiver such as smartphones and a pencil to log your record on a notebook. The goal is to find a cache, a container that includes a logbook and small items to exchange. The students can also hide a cache instead of trying to find one. There are lots of interesting hints on the geocaching website. The treasures are hidden everywhere, perhaps even at your school!

http://www.geocaching.com/
http://adventure.howstuffworks.com/outdoor-activities/hiking/geocaching.htm

Other small learning activity:

1) Create a constellation of satellites. Show the students some pictures or illustrations of GPS satellites and the satellite constellation. Then provide some materials (clay, paper, straws, etc.) to create satellites. Place the satellites around a globe that represents the Earth.

2) Play the classic battleship game. Make a 10x10 grid by yourself or simply use the printable battleship sheets online. Discuss the relationship with this game and the concept of latitude and longitude.