Global Positioning System for the Classroom – Teachers' Guide

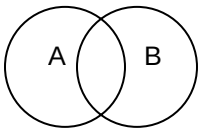
Curriculum Note:
This document corresponds with the slideshow titled "Global Positioning Systems for the Classroom."

Technical Note:
This document is specific for the Garmin Legend GPS unit. The information is applicable for any GPS unit, however the specific steps and menu options may differ.

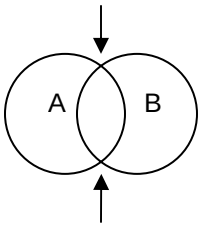
Narrative for Slideshow: "*Global Positioning Systems for the Classroom"*.

1. Title slide: Global Positioning Systems for the Classroom, Mark Musselman – This slideshow and narrative cover the basics of GPS technology, use, and classroom applications.
2. Where is the SCGA? Looking at the Google Earth image of Columbia around the University of South Carolina campus, ask participants if they can identify the location of the South Carolina Geographic Alliance (SCGA) office.
3. Note that the SCGA office is "southeast of the lawmakers" located in the state Capitol.
4. Note that the SCGA office is "east of the books" in the Thomas Cooper Library.
5. Note that the SCGA office is "southeast of the old campus," which was located around the Horseshoe.
6. Note that the SCGA office is "close enough to smell the food" from the Russell House cafeteria.
7. Note that the SCGA office is located in the Callcott Building.
8. Ask participants, "Would any of the previous descriptions have been sufficient for a person to find the SCGA in this building?" Ask if there is a more precise method to describe your location on the Earth's surface. Participants should mention the latitude and longitude coordinate system. The image shows the Earth as seen from the moon during an Apollo mission.
9. Latitude and longitude coordinates can be shown several ways with the most commonly used being "degrees, minutes, seconds (of arc)," "decimal degrees or degrees.degrees," and "degrees, minutes.minutes." For example, the coordinates for the SCGA office could be shown as [33^{o} 59' 45.95" N, 081^{o} 01' 34.43" W or 33.99608^{o}N, 081.02622^{o}W or 33^{o} 59.765' N, 081^{o} 01.573' W].
10. Latitude (is "fatitude" around the waist of the Earth) and is measured *north* and *south* of the Equator. Values of latitude are positive for the Northern Hemisphere and negative for the Southern Hemisphere. The Equator is a Great Circle similar to every line of longitude. Each circle created by a line of latitude becomes smaller as they move from the Equator toward a pole. At the poles, the latitude is actually a point.
11. Longitude is measured *east* and *west* of the Prime Meridian, which has a value of 0^{o}. The beginning point for measuring longitude could run through any point on Earth. However, the meridian that runs through the Royal Observatory in Greenwich, England was selected as the Prime Meridian. *The Greenwich Meridian was chosen as the Prime Meridian of the World in 1884. Forty-one delegates from 25 nations met in Washington DC for the International Meridian Conference. By the end of the conference, Greenwich had won the prize of Longitude 0º by a vote of 22 to 1 against (San Domingo), with 2 abstentions (France and Brazil). Why Greenwich? There were two main reasons for the choice. The first was the fact that the USA had already chosen Greenwich as the basis for its own national time zone system. The second was that in the late 19th century, 72% of the world's commerce depended on sea-charts which used Greenwich as the Prime Meridian. The decision, essentially, was based on the argument that by naming Greenwich as Longitude 0º, it would be advantageous to the largest number of people. Therefore the Prime Meridian at Greenwich became the centre of world time, and will be the official starting point for the new Millennium. (http://www.nmm.ac.uk/server/show/conWebDoc.1343)*
12. ***Minutes*** (represented as ') and ***seconds*** (represented as ") of arc are different than the minutes and seconds on a clock. Actually, 1 hour of Earth's rotation covers 15^{o} (360^{o}/24 hrs = 15^{o}), so 1 hour of Earth rotation equals 15^{o}=900 minutes of arc=54,000 seconds of arc (1^{o}=60'=3600").
13. Key lines of latitude are the Equator (0^{o}). The Equator divides the Earth into the Northern and Southern Hemispheres.
14. Key lines of latitude include the North Pole, which is actually a point at 90^{o}N.
15. Key lines of latitude include the South Pole, which is actually a point at (-90^{o} or 90^{o}S).

16. Key lines of latitude include the Tropic of Cancer at 23.5°N.
17. Key lines of latitude include the Tropic of Capricorn (-23.5° or 23.5°S).
18. Key lines of longitude are the Prime Meridian (0°) and the 180th Meridian (180°E and 180°W, which is also generally the International Date Line). The Western and Eastern Hemispheres are measured west and east of the Prime Meridian to where they meet at the 180th Meridian.
19. The combination of a latitude coordinate and a longitude coordinate designates a unique point on the surface of the Earth. Ask participants to answer "true or false" to the statement, "The coordinates x°S/y°W is **not** a point within the United States."
20. Even without values for x and y, you can answer that the statement is true because no U. S. points lie within the Southern Hemisphere.
21. The basis of Global Positioning System (GPS) is triangulation from a selection of the 24 satellites in known Earth orbit. The system was originally designed by the Department of Defense, which continues to operate the program.
22. To "triangulate," a GPS receiver measures distance between the receiver and the satellite using the travel time of radio signals. The formula is *speed x time = distance*, where speed is assumed to be the speed of light at approximately 300,000 km/sec. The GPSr knows where the satellites are located and how long it took the signal to travel from the satellite at the assumed speed, so the distance between the GPSr and the satellite can be determined.
23. The location of the GPSr can be determined with three or more similar satellite calculations. Mathematically we need four satellite ranges to determine exact position. Three intersecting ranges are enough if we reject ridiculous answers (points in the center of the Earth or high in the atmosphere).



Using only two satellites (A and B), you could be anywhere within the intersection of sphere A and sphere B.



Sphere C intersection points

The sphere of satellite C will intersect the area between sphere A and sphere B in only two spots. Your location can be determined by eliminating the location that is within the planet or high into the atmosphere. A 4th satellite signal sphere would only intersect the three other spheres in one location thereby determining the user's precise location.

24. GPSr accuracy is diminished by:
    a. Clock inaccuracies within the satellites. The GPS unit will calculate an incorrect time component for the equation.

   b. Satellite location inaccuracies. The GPS unit will begin measuring the distance solution from the incorrect location if the satellites are not exactly where they are stated to be.
   c. Atmospheric signal interference
   d. Signal interference caused by obstructions (trees, buildings, mountains, etc.). The signal is weak and needs to be near line-of-sight. Natural features or human-made features can cause the signal to reach the GPS unit as a reflected signal, which would affect the time component of the equation as the signal would take longer than actual distance would require.
   e. Number of satellites available to the user (above the horizon) and their positions in relation to each other (in a line or scattered). The user's location can be more quickly and accurately determined if the satellites are more widely spread apart.

25. Although a GPSr can look similar to a Personal Data Assistant (PDA) or a cell phone, it has a completely different function.
26. The Garmin Legend is the GPSr that is available from the SCGA for use by teachers. There are currently 7 units available. The following slides will describe the basic operation of this unit, though most GPSr operate in a similar fashion. The power button is at the bottom on the right of the unit. Hold down this button until the initial screen appears. Press and hold the same button for 3 seconds and the GPSr will power off. Refer to the *Global Positioning Systems:Setting Up a GPS Course* PowerPoint and narrative for additional information on operating a GPS unit and for setting up a course to provide GPS instruction and practice for faculty and students.
27. Press the top button on the right side three times to bring up the satellite page. One can scroll through the pages by continuing to push this button.
28. The thumb toggle switch is used to navigate within a screen like a mouse with a computer. The toggle's current location on the screen is shown by the darkened "highlighting". The toggle switch only allows navigation in the four cardinal directions. Pushing directly down on the center of the thumb toggle is the selection option like the "enter" key on the keyboard.
29. The basic pages for the GPS unit are the satellite page, the map page, the navigation page, the trip computer page, and the main menu page. The following slides will address all but the map and the trip computer pages. The map page is self-explanatory. Your current position will be shown on a map and will move as you move. The trip computer page shows various statistics regarding the trip currently being taken.
30. The Satellite Page shows satellite positions, signal strength, and accuracy along with the user's current location. The dot in the center of the two circles represents the location of the GPSr user. This page along with the navigation page will be the most used pages.
31. The inner circle on the satellite page represents points at 45^{o} from the horizon, while the outer circle represents points at the horizon. Therefore, satellites shown closest to the center dot are more directly overhead of the GPSr user, while satellites shown farthest from the center dot are at or near the horizon. See #24 above for problems with signal strength and location accuracy.
32. The "pages" icon in the upper right corner of the screen provides a drop-down menu for the various sections of the GPSr. Under the "Main Menu" option is the "Mark" icon, which is used to record the GPSr user's current position. Pressing and holding down the center of the toggle switch for two seconds will accomplish the same thing. The waypoint is assigned a 3-digit name.
33. Selecting "ok" saves the waypoint with the assigned name.
34. The waypoint name can be changed to a more descriptive name by using the thumb stick to toggle down to the waypoint field. Once the waypoint field is highlighted, pushing down on the center of the thumb stick produces an alpha/numeric keyboard. Using the thumb stick to scroll around the keyboard and selecting highlighted characters or numbers, the user can enter a new waypoint name. The coordinates can also be changed in the same manner.
35. Waypoints can be entered in advance of a trip. Waypoints can be downloaded directly from a computer using free software such as EasyGPS at http://www.easygps.com/, which accommodates most GPS models. This is beneficial if trails are not well-marked or there are multiple intersections. By loading the waypoints that highlight critical intersections and routes into the GPSr prior to a trip, there will be no confusion once on trail.
36. For example, all 280 waypoints (including trailheads, camp sites, water, & major junctions) of the Foothills Trail in SC can be downloaded at http://www.travelbygps.com/premium/foothills/foothills.php. Similarly, up to 500 geocaching waypoints can be downloaded at a time from www.geocaching.com.

37. Pre-trip waypoints can be displayed on topographic maps, which can be loaded to a GPS unit. A desire for the easiest route is all the motivation one needs to understand contour lines. Conversely, the GPSr can periodically capture the user's location during a trip and the waypoints can be loaded onto a map at the end of the trip to show the exact route.
38. Just as the name of a waypoint can be changed, so too can the location (coordinates). This can be accomplished by toggling down until the location field is highlighted and pressing the center of the thumb stick to reveal a number keypad for editing.
39. If a waypoint screen is already displayed, simply toggle to the Goto button and press the center of the thumb stick. The navigation page will appear showing the bearing and distance to the waypoint.
40. If there are already waypoints loaded to the GPS unit, pressing the bottom button on the left side will reveal the available options. Selecting "Waypoints" reveals options to display the waypoints by name or by the nearest to your current position.
41. The Navigation Page is used to navigate to a waypoint. This page appears once a waypoint has been selected from the waypoint list (push the bottom left button) and the "GoTo" option has been selected at the bottom left of the screen. The Navigation Page shows the destination waypoint at the top of the page along with the bearing and distance to that waypoint from the user's current position. A compass is shown in the center of the screen and can cause some confusion to new GPSr users. (see below)
42. Beginning GPSr users often become confused by the compass incorporated within the unit. This is a graphic representation and not a magnetic compass. When turned on, the unit does not know how the individual is oriented. The bearing to the target is accurately depicted on the screen, but the arrow on the compass may not (and most likely will not) be pointing the correct "direction" from the user's perspective. Once the user takes a few steps, the unit can determine the correct orientation and the compass arrow will swing around so that the bearing shown on the screen will match the "direction" for the user. For example, the user turns on the unit and requests to "go to" a certain waypoint. The waypoint may be 1000 meters behind the user, but the GPSr does not know if the user is facing the target point, is facing away from the target point, or is at a 90^{o} angle to the target point. The unit will accurately depict that the target point is on a bearing of X degrees from the point where the user is standing and the compass arrow on the screen will point to X degrees on the screen. The bearing is correct with respect to the Earth's magnetic field, but the compass arrow depicted on the screen is not magnetic and will not align with the Earth's magnetic field. Therefore, as the user views the screen, the arrow on the screen might be pointing away from the user. Since the target point is to the user's rear, this "direction" would be 180 degrees "off". Once the user takes a few steps, the GPSr can determine "the user was there, now the user is here and moving away from the target" and the compass arrow will spin around to direct the user to reverse course. Henceforth, the GPSr will not have difficulty matching the compass arrow to the correct direction of travel (assuming the user does not walk backwards!).
43. The GPSr is powered by batteries. If the batteries fail or if the GPSr is dropped and rendered inoperable, the user may need some other means of navigation. An inexpensive magnetic compass, a map of the area, and the skills to use both are essential if the user will be operating in remote or less-populated areas.
44. Turn off the unit whenever practical to conserve battery life. Remember, batteries will ALWAYS fail at the most inconvenient moment. Push and hold bottom button on the right side until screen clears.
45. "*Geocaching is an entertaining adventure game for gps users. Participating in a cache hunt is a good way to take advantage of the wonderful features and capability of a gps unit. The basic idea is to have individuals and organizations set up caches all over the world and share the locations of these caches on the internet. GPS users can then use the location coordinates to find the caches. Once found, a cache may provide the visitor with a wide variety of rewards. All the visitor is asked to do is if they get something they should try to leave something for the cache.*" -- http://www.geocaching.com/faq/. See…
46. "*A cache can come in many forms but the first item should always be the logbook. In its simplest form a cache can be just a logbook and nothing else. The logbook contains information from the founder of the cache and notes from the cache's visitors. The logbook can contain much valuable, rewarding, and entertaining information. A logbook might contain information about nearby attractions, coordinates to other unpublished caches, and even jokes written by visitors. If you get some information from a logbook you should give some back. At the very least you can leave the date and time you visited the cache.*

Larger caches may consist of a waterproof plastic bucket placed tastefully within the local terrain. The bucket will contain the logbook and any number of more or less valuable items. These items turn the cache into a true treasure hunt. You never know what the founder or other visitors of the cache may have left there for you to enjoy. Remember, if you take something, its only fair for you to leave something in return. Items in a bucket cache could be: Maps, books, software, hardware, CD's, videos, pictures, money, jewelry, tickets, antiques, tools, games, etc. It is recommended that items in a bucket cache be individually packaged in a clear zipped plastic bag to protect them.

What shouldn't be in a cache?

Use your common sense in most cases. Explosives, ammo, knives, drugs, and alcohol shouldn't be placed in a cache. Respect the local laws. All ages of people hide and seek caches, so use some thought before placing an item into a cache.

Food items are ALWAYS a BAD IDEA. Animals have better noses than humans, and in some cases caches have been chewed through and destroyed because of food items in a cache. Please do not put food in a cache." -- http://www.geocaching.com/faq/

47. ***Cache*** - (kash) *n*. 1. a hiding place for treasure or provisions. 2. hidden treasure or provisions. (**caching**) to place in a cache; [not to be confused with *cachet*]
    a. Caches generally contain a logbook to sign and enter comments, a writing implement for the forgetful geocacher, and items of various usefulness and value to trade. If an item is removed, an item should be placed in the cache so that the cache is never empty. Geocachers are also encouraged to log their finds on the cache's web page.
    b. Caches are placed at the whim of the individual, but often are placed in a location that the hider wishes to share due to the location's uniqueness or its beauty or its absence from any tourist guide.
48. Each cache has a name,…
49. …a waypoint designation,…
50. …latitude/longitude coordinates and…
51. …a difficulty/terrain rating.
52. Cache containers vary in size from film canisters (micro) to very large ammunition containers. They can also be "virtual," which means that there is not an actual container, but the geocacher needs to discover some information or take a picture of an object at the given coordinates.
53. The cache page will contain varying amounts of background information regarding the cache, its owners, history of the site or region, or helpful hunting tips.
54. An encrypted clue is sometimes provided for geocachers unable to find the cache using the coordinates alone. Links to topographic maps, aerial photography, Google Earth and MapQuest street maps help the geocacher plan their attack on the cache or find a way around obstacles, since the GPSr gives an "as the crow flies" bearing. Other links take a user to the pages of caches nearest to the cache that they are viewing.
55. Finally, the cache page offers the geocacher a place to log their find and describe their experience. Logs can be as simple as "Found it" to detailed description about the joys or any difficulties encountered during the search. It is poor form to add clues or any information known as "spoilers" that would give away the location or hiding techniques.
56. Conclusion slide: GPS technology continues to be incorporated into various aspects of our society. Understanding the concepts behind the technology as well as its use not only helps students address curriculum standards, it is an ever-increasing employment skill. A simple campus-based navigation course, geocaching, or incorporation within the curriculum are easy, effective methods for teaching students GPS skills and technology! See the *Global Positioning Systems: Setting Up a GPS Course* slideshow and narrative for detailed instructions for setting up a navigation practice course on campus.

Author Credit: Mark Musselman, Audubon Center at Francis Beidler Forest, Harleyville, South Carolina