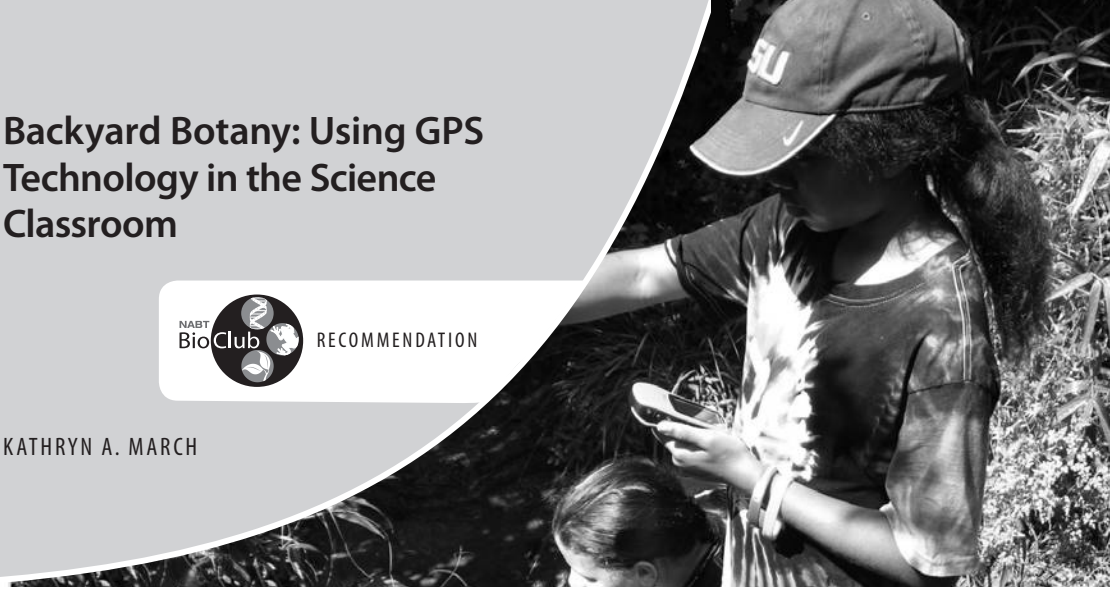
INQUIRY & INVESTIGATION

Backyard Botany: Using GPS Technology in the Science Classroom

NABT BioClub RECOMMENDATION

KATHRYN A. MARCH



Abstract

Global Positioning System (GPS) technology can be used to connect students to the natural world and improve their skills in observation, identification, and classification. Using GPS devices in the classroom increases student interest in science, encourages team-building skills, and improves biology content knowledge. Additionally, it helps educators meet the ISTE's Educational Technology Standards and the National Science Education Standards while increasing the environmental literacy of their students. This paper provides suggestions for utilizing GPS technology in student-led explorations of the local flora, as well as other innovative ideas for using these devices in science instruction.

Key Words: *GPS; geocaching; technology; trees; botany; plants.*

"It's a good thing to learn more about nature in order to share this knowledge with children; it's even better if the adult and child learn about nature together. And it's a lot more fun." – Richard Louv, *Last Child in the Woods*

Working in an informal science education facility over the last several years has given me many opportunities to introduce children to handheld Global Positioning System (GPS) units. I wish I had known about the multitude of potential applications for this technology when I was teaching high school biology. This article introduces some ways of using GPS technology in a middle or high school science classroom. Specifically, I offer suggestions for integrating this technology into your existing lessons about plants.

This article introduces some ways of using GPS technology in a middle or high school science classroom.

I developed this idea from a popular activity called "geocaching." The website http://www.geocaching.com describes geocaching as a global scavenger hunt, in which the goal is to find a hidden object (see Figure 1) using a set of latitude–longitude coordinates. These coordinates are shared with participants via the Internet. Handheld GPS devices are required for this game, to determine the distance and direction to the final coordinates.

The idea of using GPS technology to find plants instead of geocaches is not entirely new. In the Summer 2003 volume of *American Forests* magazine, photojournalist Tim Wright wrote about the possibility of publishing the lat–long coordinates of trees listed in the National Register of Big Trees. Making these locations public would allow nature-lovers to use GPS technology to hunt for the trees, in the same way that geocachers hunt for hidden prizes. In this article, I take Wright's idea of "trees as treasure" a step further and discuss how GPS technology can be used not only to search for trees, but also to help your students learn more about them.

Why GPS Technology?

Using GPS devices to introduce students to the plants growing around your school helps to meet the *National Educational Technology Standards* set forth by the International Society for Technology in Education. Specifically, this activity helps to meet Student Standards 1, 2, 4, and 6 by encouraging them to demonstrate creativity and innovation; communicate and work collaboratively, use critical thinking, problem solving, and decision-making skills; and demonstrate an understanding of technology (International Society for Technology in Education, 2007). Activities involving GPS technology also provide active-learning situations (Figure 2) that align with Content Standards A, C, E, and G of the *National Science Education Standards* (Science as Inquiry, Life Science, Science and Technology, and History and Nature of Science, respectively). Finally, the National Research Council (NRC) has recommended providing more real-world, authentic experiences in science education (NRC, 1996). Working with live plants helps to meet this recommendation better than models or pictures.

Further, taking students outside for science lessons is an idea that continues to gain popularity and support nationally. The National No Child Left Inside Coalition has proposed an amendment to the No Child Left Behind (NCLB) Act to add incentives for states to develop environmental literacy plans and promote more

The American Biology Teacher, Vol. 74, No. 3, pages 172–177. ISSN 0002-7685, electronic ISSN 1938-4211.
DOI: 10.1525/abt.2012.74.3.8

Figure 1. Program participants finding a geocache.

Figure 2. Using GPS technology promotes active learning and builds problem-solving skills.

outdoor experiences during classroom instruction (National NCLI Coalition, 2010). Serious environmental issues face the next generation, and it is critical that students have a basic level of environmental literacy to prepare them to face environmental challenges as adults. Yet children are becoming increasingly disconnected from the natural world, a condition often called "nature-deficit disorder" (Louv, 2005). Fostering personal connections between your students and nature is an important part of developing environmental literacy.

This lesson will help make your students more aware of the plants living around them. The phenomenon known as "plant blindness" was first suggested by Wandersee and Schussler (1999). They defined plant blindness as

> the inability to see or notice the plants in one's own environment – leading to (a) the inability to recognize the importance of plants in the biosphere, and in human affairs; (b) the inability to appreciate the aesthetic and unique biological features of the life forms belonging to the Plant Kingdom; and (c) the misguided, anthropocentric ranking of plants as inferior to animals, leading to the erroneous conclusion that they are unworthy of human consideration. (Wandersee & Schussler, 1999; in Prakash, 2010)

Providing lessons that promote interaction with living plants can help to combat plant blindness.

○ Suggested Lesson: A Field Guide to the Trees in Your Town

In a traditional classroom setting, I would use GPS technology to facilitate a lesson on the plants found in our town. Specifically, I would ask my students to create a field guide of the trees growing either on school property or at a local park. For a class of 25–30 students, this involves programming at least five GPS devices ahead of time with the locations of the different tree species. Some ideas for preparing and executing a lesson like this one are outlined below.

Materials Needed

- 5–6 GPS units (preprogrammed)
- Field guides to local trees
- Field notebooks and pencils
- Digital camera (optional)

Overview & Objectives

Start by familiarizing your students with the type of information that is often found in botanical field guides. How are different guides organized? What types of images do they use? What textual information

do they contain? Divide your students into teams. Ask each team to develop a data organizer for creating a field guide. What information will they collect in the field? What images will they include? Next, acquaint them with GPS technology and explain your expectations for their field time. Each team will be navigating to several preprogrammed coordinates, correctly identifying several species of trees, and collecting sufficient data for their guides.

Your students should arrive in the field prepared to identify the trees you have chosen. This can be accomplished using field guides or previous classroom instruction. Ask them to write descriptions in their field notebooks and to draw the characteristics they used to identify the species, such as the bark, leaves, and so on. Alternatively, they might take digital pictures. Back in the classroom, each team should create their field guide using their notes and images. You may also want your students to complete some additional research on the species they found.

A minimum of 3 hours of class time is needed for this activity. In the first hour, focus on familiarizing your students with field guides and the devices, as well as a brief discussion of practical considerations. Your students will need at least an hour outside; however, this will vary considerably depending on how many waypoints you program, how far apart they are, and what you expect students to accomplish at each location. For the field-guide activity, students will need about 10–15 minutes per waypoint. Plan for at least another hour back in the classroom to create the final field guides; again, this will vary depending on your expectations.

For students who have not been exposed to these concepts, I recommend following up the outdoor activity with a lesson on how latitude and longitude are determined. It's often beneficial to discuss how this coordinate system is used in the life sciences. A great example is the Journey North project, which tracks the southern migration of animals, and the northward progression of spring through the blooming of plants such as tulips (see http://www.learner.org/jnorth/).

The major objectives of this project are for students to learn to use GPS technology efficiently, work effectively as a team, identify local plant species successfully, and create an accurate and attractive field guide to the trees. Although 3 hours may seem like a significant amount of time to invest in this activity, consider that it can potentially meet a number of your existing curricular objectives. This lesson can serve as an alternative to more traditional methods of teaching about the characteristics of plants, specific botanical structures, and how organisms are classified. At the same time, it provides an opportunity for student inquiry while utilizing current technology. This multidisciplinary lesson encourages the development of team-building skills through an authentic, real-world problem that connects botany and biology to environmental science, math, and geography.

○ Assessment Possibilities

There are a wide range of possibilities for evaluating the outcomes of this activity, depending on the level of your students and the

Table 1. Sample rubric for assessing students' field guides. Adapted from RubiStar's customizable rubric template: "Making a Brochure."

	Accomplished	Average	Developing	Beginning
Attractiveness & Organization	Exceptionally attractive formatting and well-organized information.	Attractive formatting and well-organized information.	Well-organized information, but could be more attractive to the reader.	The formatting and organization of material are confusing to the reader.
Content Accuracy	All facts in the field guide are accurate.	Most of the facts in the field guide are accurate.	Some of the facts are accurate, but some are inaccurate or missing.	Most of the facts are inaccurate, or facts are missing from the guide.
Knowledge Gained	Student can accurately answer all questions related to the facts and technical processes used.	Student can accurately answer most questions related to the facts and technical processes used.	Student can only accurately answer some questions related to the facts and technical processes used.	Student appears to have little knowledge about the facts or technical processes used.
Graphics & Pictures	Graphics go well with the text and there is a good mix of text and graphics.	Graphics go well with the text, but they are not well balanced (there are too many or not enough graphics).	There is a good mix of text and graphics, but the graphics do not go with the text or appear to be randomly chosen.	Graphics do not go with the text or they appear to be randomly chosen; also, the graphics and text are not well balanced.
Sources	Complete and accurate citations used to document facts and images not generated by the student.	Mostly complete and accurate citations used to document facts and images not generated by the student.	Only some citations are complete and accurate for the facts and images not generated by the student.	Sources are not documented accurately for most of the facts and images.

specific assignment that you create. Using a rubric to assess the field guides is one option (see Table 1). I created this rubric using RubiStar, a free online tool from the Advanced Learning Technologies project at the University of Kansas Center for Research on Learning (http://rubistar.4teachers.org). You can access RubiStar at http://rubistar.4teachers.org.

○ Implementation Suggestions

Choosing a GPS Unit

There are many different models of GPS units available on the market, and looking for one can seem overwhelming at first. If you're purchasing GPS units for the first time, be sure to choose a hiking model. Help can be found at http://www.geocaching.com/about/buying.aspx. Also, my experience teaching hundreds of children how to use GPS devices has taught me this: the fewer buttons, the better (see Figure 3). It takes less time to familiarize your students with the device if there are fewer button combinations to access the different menus. Regardless of the model, there are two main functions you will need to know before using a GPS in the classroom – programming coordinates, and accessing them later.

Teacher-Created Waypoints

Saved sets of coordinates are called "waypoints." Before your students begin using the devices, you may wish to preprogram them with one or more waypoints. In virtually all hiking GPS units, the main menu will have an option labeled "mark." The mark function saves the latitude and longitude coordinates of the spot on Earth where you are currently standing. This set of coordinates can then be modified to whatever values you wish. However, I find it easier to take the GPS units to the physical locations I want to program, as shown in Figure 4. At each spot, I simply press "mark" on each unit to save my current location. If you choose this method, be sure to keep a master list of which locations correspond to which waypoint identifiers in the device (most will label waypoints numerically: "001," 002," etc.). Otherwise, you may not remember which tree corresponds to waypoint 009. If you enter the coordinates yourself, your introductory lesson for your students need only include instructions on how to access the saved waypoints.

Student-Created Waypoints

If you prefer to let your students enter the waypoints, use a single GPS unit to mark each location ahead of time. I suggest writing the latitude and longitude coordinates on the board or printing out a list for your students. For each location, your students will need to use the mark function to save a new waypoint. The device will default to their current location, which can then be modified to reflect the latitude and longitude values you provide.

Accessing Waypoints

Regardless of who enters the waypoints, accessing them on the day you're headed outside is fairly simple. Almost all hiking GPS models have a menu option called "waypoints." This is just a list of all of the latitude and longitude coordinate sets saved in the device. The list is typically organized by waypoint name. Once a waypoint is selected, the device will most often have an option labeled "goto." Selecting this option results in the device telling you how to "go to" the waypoint from your current location. In many models, selecting goto for a waypoint brings up an electronic compass indicating the direction of travel. This screen also typically provides the distance to the waypoint and other useful information. To prevent teams from getting in each other's way, I recommend directing them to navigate to the waypoints in different orders

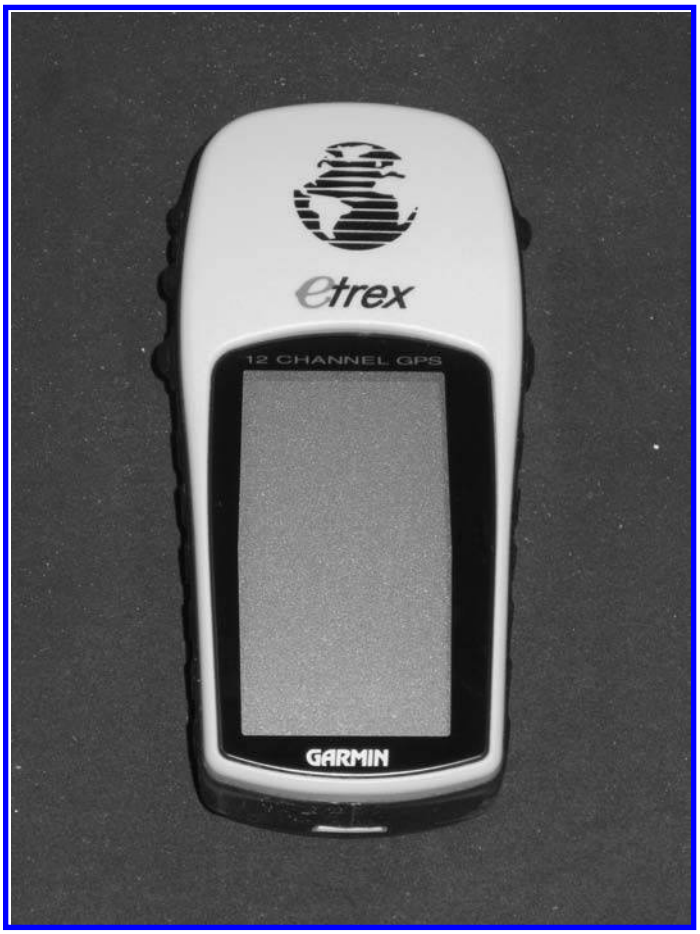


Figure 3. Units with fewer buttons, such as Garmin's eTrex, may be easier for your students.

Figure 4. A trip to the physical locations you want your students to find is the easiest way to program coordinates.

(e.g., team 1 navigates to waypoint 001 while team 2 begins at waypoint 002).

○ Practical Considerations

There are some important practical considerations for new GPS users. First of all, instruct your students to keep moving for the units to stay updated. Also, remind them that the units are most accurate outside because they rely on satellite communication. If your students set up the devices to "goto" their first waypoint before they leave the building, be sure to instruct them to ignore the information given by the compass screen until they are outside.

The nature of GPS technology is that the units will always give distance and direction as the crow flies. This can cause confusion for new users; I have had children who wanted to scale a wall or wade through a river because "that's what the GPS says to do." I've found it's important to explain to students beforehand not to be overly dependent on the device. Part of successfully utilizing this technology is problem-solving; most of the time your students are not going to be able to walk straight from the door of the building to their target.

Another limitation of this technology is that it has a certain amount of inaccuracy with small distances. Once the students are within 15 feet of their destination, the GPS unit can no longer distinguish between the target and their current position. Not only is it important to warn your students of this limitation, but also be aware of it when creating waypoints. Choose trees or plants standing alone, or provide your students with additional information if there are several species within 20 feet of your intended target.

○ Other Concerns

In my experience, children find GPS technology so engaging that there are few issues related to student behavior. However, if you have concerns about student supervision during this activity, there are several options to consider. You can set waypoints in a circular pattern around a central location from which you can observe all your groups simultaneously. Consider having students work in fewer, larger groups so that you can monitor them more easily. You might even enlist the help of adult volunteers; many adults will find this just as interesting as your students and will be happy to tag along.

If you aren't sure how to get GPS devices for your classroom, begin by inquiring about your school or department's existing technology budget. You can currently purchase a Garmin eTrex for around $100; that's only $500 for a class of 30 students, and they can be used by hundreds of students every year. If you need grant money, there are many resources for teachers. One website I recommend is http://www.technologygrantnews.com/. Also, the Environmental Protection Agency (http://www.epa.gov/enviroed/grants.html) annually offers grants to teachers who are engaged in environmental education activities. If it is not possible to obtain GPS units, you could try an alternative activity called "waymarking," which uses compasses instead. The website http://www.waymarking.com explains this fun alternative in detail.

Finally, if you are located in an urban school district, I recommend utilizing a nearby park or public garden for this activity. Try your local university or college; it is likely to have at least one open green space that is accessible to the public. Include your students in your search by asking them to brainstorm a list of places you could go.

○ Further Lesson Ideas

Scavenger-hunt-type activities are popular with all ages. You could give your students a list of plant species they have to find on the grounds, and they could use the mark function on the GPS to prove they were in the right places. Students could create scavenger hunts for each other, such as a list of tasks for their classmates to complete (e.g., "Navigate to these coordinates and draw a picture of the flowers you find there"). Your students could fill plastic boxes (I call them "clue-caches") with items and hide them for their classmates. Perhaps these hidden boxes contain review materials for a unit exam, or puzzles for students to solve.

Also, this technology can be used to record the exact location where a plant specimen was found. You could then create specimen cards that include latitude and longitude coordinates. Both middle and high school students enjoy making herbariums. Not only is this a great way to model botanists' behavior, it's also practical for you. Next year, you can send out your students to the previously recorded locations, to see if the plants are still growing there.

With enough GPS units and a bit of preparation, you could even administer an outdoor "field practical" to your high school students. Assessment questions could include tree identification; describing the function of a labeled part of a plant; or the completion of a task, such as determining the age of a tree stump. You could also test their orienteering ability or their mastery of the GPS unit's functions.

Finally, you could even use this technology to monitor the spread of invasive species, perform surveys of endangered plants, or record other plant species of importance in your local community. The American Society of Plant Biologists (http://my.aspb.org), the Botanical Society of America (http://www.botany.org), and the National Parks Service (http://www.nps.gov) all offer plant-related lessons that could be modified to incorporate GPS technology. The possibilities are endless!

○ Key Vocabulary

Geocaching – a global scavenger hunt involving hidden objects and GPS units.
GPS – acronym; stands for Global Positioning System.
GPS unit – a handheld device that uses satellites to determine location on Earth.
Herbarium – a collection of preserved plant specimens.
Latitude – a measure of distance north or south of the Equator.
Longitude – a measure of distance east or west of the Prime Meridian.
Waypoint – a set of latitude and longitude coordinates.

○ Acknowledgments

I thank Dr. Jim Wandersee of Louisiana State University for his guidance and support in writing this article. I also thank Claire Coco, director of the Bluebonnet Swamp Nature Center in Baton Rouge, LA, for sharing her knowledge of both geocaching and nature-based education.

References

International Society for Technology in Education. (2007). *National Educational Technology Standards for Students*. Washington, D.C.: International Society for Technology in Education.

Louv, R. (2005). *Last Child in the Woods: Saving Our Children from Nature-Deficit Disorder.* Chapel Hill, NC: Algonquin Books.

National NCLI Coalition. (2010). About the No Child Left Inside Act. Available at http://www.cbf.org/Page.aspx?pid=948.

National Research Council. (1996). *National Science Education Standards.* Washington, D.C.: National Academy Press.

Prakash, B. (2010, June 2). Plant blindness: What research says. *Eco Walk the Talk*. Retrieved from http://www.ecowalkthetalk.com/blog/?p=3069.

Wandersee, J. & Schussler, E. (1999). Preventing plant blindness. *American Biology Teacher*, *61*, 82–84.

Wright, T. (2003). Geocaching: trees as treasure. *American Forests*, *109*(2), 7.

KATHRYN A. MARCH is a Ph.D. student in Biology Education at Louisiana State University, 22 Karen Drive, Covington, LA 70433. E-mail: kmarch1@lsu.edu.