

Using GPS and Geocaching Engages, Empowers and Enlightens Middle School Teachers and Students

Abstract

This article provides a theoretical rationale (E6 Learning Model) for creating technology-rich, constructivist learning environments that use GPS receivers and geocaching in K-12 classrooms and engage students in student-centered, personally meaningful, authentic, and collaborative learning. It also provides examples of classroom activities that incorporate GPS units and geocaching, steps for teachers to create similar lessons, and a curricular example that teachers can modify to increase student understanding of any curricular area. Finally, it provides online resources and a podcast that provide teachers with additional ideas for making GPS receivers and geocaching integral tools in their engaging, empowering, and enlightening classrooms.

Tell me, I will forget • Show me, I may remember • Involve me, and I'll understand

Introduction

Technology is an integral and growing part of daily living in the twenty-first century. The challenge, then, for teachers, is to use technology effectively in classrooms to help students take ownership for learning and develop the practical and critical thinking skills necessary to better understand the world around them. To meet this challenge, teachers can use an emerging technology tool, *global positioning systems* (GPS) receivers, and an emerging GPS-based activity, *geocaching*, to transform their middle school classrooms from teacher-centered environments to exciting, empowering, exploratory environments that focus on student engagement in the learning process.

As the world becomes more connected, managed, and observed through the use of computers and other technologies, K-12 and university students have increased opportunities to have the world at their fingertips--whether using the Internet, GPS units, satellite imagery (GoogleEarth™) or participating in a geocaching experience. Using these tools and activities gives classroom teachers opportunities to instill in students a curiosity about geography, science, mathematics and the world in which they live. GPS units are multidisciplinary, inquiry-driven, field-based tools useful across the K-12 and university curricula.

In this article, I provide a professional development model for teachers learning to use GPS units and geocaching. This model, which is equally applicable with middle school students, incorporates the characteristics of active, engaged learning and constructivist learning environments. I also provide (1) descriptions of three other GPS/geocaching workshops for a variety of audiences, (2) comments from teachers about their experiences learning to use GPS receivers and geocaching, (3) numerous online resources, and (4) concrete steps to create integrated curricular units/lessons that use GPS units and geocaching to spark student learning and raise student awareness of the world around them. Finally, I provide a podcast that gives an overview of using GPS receivers and geocaching in education.

Definition of Terms

Global Positioning System (GPS) is a \$12 billion satellite navigation system consisting of 24 satellites (plus a few spares) deployed and maintained by the U.S. Department of Defense. Each satellite passes around the earth twice in a 24-hour period at an altitude of about 12,500 miles. The satellites continuously broadcast position and time data to users throughout the world.

Deployment of the satellites began in 1978, and the system became fully operational (uninterrupted global coverage) in 1995. GPS provides satellite signals that can be processed in a GPS receiver, enabling the receiver to compute one's position on the face of the earth (often indicated in terms of latitude and longitude).

GPS Receivers (also referred to as *GPS Units*) are used in cars, boats, airplanes, and even in cellular phones. Handheld GPS receivers are carried by hikers, surveyors, mapmakers, and others who need to know where they are. The GPS device receives data from the closest satellites to determine the unit's exact location, elevation, speed, and time. Inexpensive GPS receivers available to civilians are as accurate as those used by the military today. Currently, there are millions of civilian users of GPS and GPS receivers worldwide.

A GPS receiver communicates with GPS satellites to provide information to its user. A standard GPS receiver will place the user's location on a map at any given location using latitude and longitude coordinates. It will also trace the user's path from one location to another. With this information and its built-in clock, the receiver can give users the following information:

- How far they've traveled (odometer)
- How long they've been traveling
- Their current speed (speedometer)
- Their average speed
- A "bread crumb" trail showing users exactly where they have traveled on the map
- The estimated time of arrival at a destination if the users maintain their current speed

Geocache comes from the terms *geo* (earth) and *cache* (hidden supply or treasure). Historically, explorers and miners used caches to hide food or other items for emergency purposes. People still hide caches of supplies today for similar reasons. Animals and birds also hide food in caches for later use. Today's geocaches are usually inexpensive trinkets or clues in waterproof containers with the cache's coordinates. These coordinates, along with other details of the location, are posted on the Internet so other geocachers obtain the coordinates and seek out the cache using their GPS handheld receivers.



A typical geocache used in workshops

Geocaching is an engaging adventure activity for GPS users. Locating a geocache is a good way to take advantage of the 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. See a [video](#) on geocaching.



The author conducting a GPS/geocaching workshop with ASU graduate students

Review of Research

Since GPS receivers are emerging technologies, and geocaching is an emerging educational strategy, there is little, if any, formal research on these topics. However, there is extensive research on how constructivist learning environments engage students and enhance

learning. This paper espouses the use of GPS receivers and geocaching to help create such student-centered learning environments.

The International Society for Technology in Education (ISTE, 2006) maintains that traditional educational practices no longer provide students with all the necessary skills for survival in today's world. They believe that today's students must apply strategies for solving problems using appropriate tools for learning, collaborating, and communicating. Further, they suggest that teachers seek to create new learning environments that facilitate such strategies.

The following chart from ISTE lists characteristics representing traditional approaches to learning and corresponding strategies associated with new learning environments:

Table 1. A comparison of traditional and new learning environments

Traditional Learning Environments	New Learning Environments
Teacher-centered instruction	Student-centered learning
Single sense stimulation	Multisensory stimulation
Single path progression	Multipath progression
Single media	Multimedia
Isolated work	Collaborative work
Information delivery	Information exchange
Passive learning	Active/exploratory/inquiry-based learning
Factual, knowledge-based learning	Critical thinking and informed decision-making
Reactive response	Proactive/planned action
Isolated, artificial context	Authentic, real-world context

ISTE (2006) states that learning environments should prepare students to:

- Communicate using a variety of media and formats
- Access and exchange information in a variety of ways
- Compile, organize, analyze, and synthesize information
- Draw conclusions and make generalizations based on information gathered
- Know content and be able to locate additional information as needed
- Become self-directed learners
- Collaborate and cooperate in team efforts

The theoretical basis for this article is constructivism. "Constructivism does not claim to have made earth-shaking inventions in the area of education; it merely claims to provide a solid conceptual basis for some of the things that, until now, inspired teachers had to do without theoretical foundation" (von Glasersfeld, 1995, p. 15). Jonassen (1991) notes that many educators and cognitive psychologists have applied constructivism to the development of learning environments. Teachers, he believes, should create real-world, context-rich environments in which learning is relevant and should focus on concrete approaches to solving real-world problems. They should also serve as coaches and mentors as students solve these problems. Additionally, they will want to stress conceptual interrelatedness and provide tools and environments that help learners interpret the multiple perspectives of the

world. Scaffolding is also beneficial for students as they seek to control and mediate their own learning

Jonassen (1994) further summarizes how knowledge construction can be facilitated by teachers who focus on knowledge construction, not reproduction; present authentic tasks (contextualizing rather than abstracting instruction); and provide real-world, case-based learning environments, rather than pre-determined instructional sequences. He also encourages teachers to enable context- and content-dependent knowledge construction, support collaborative construction of knowledge through social negotiation, and represent the natural complexity of the real world

Wilson & Cole (1991) reiterate these principles and note the importance of using errors as a mechanism to provide feedback to learners' understandings. Honebein (1996) notes several other goals for the design of constructivist learning environments, such as providing experience with the knowledge-construction process and offering various modes of representation; embedding learning in realistic, relevant, and social contexts; and encouraging ownership and self-awareness in the learning process.

According to Vygotsky (1978), students' problem solving skills fall into three categories:

1. Skills that the student cannot perform;
2. Skills that the student may be able to perform; and
3. Skills that the student can perform with help.

Scaffolding, the process of guiding the learner from what is presently known to what will be known, allows students to perform tasks that would normally be slightly beyond their ability without guidance from the teacher. When teachers scaffold student learning, students often take greater responsibility for their own learning and challenge themselves to go beyond both teacher and individual expectations.

Murphy (1997) synthesizes the research on constructivism in education during the last 20 years. Several other important tenets of constructivist learning that underlie the GPS/Geocaching Workshop described in this article follow:

- Primary sources of data are used in order to ensure authenticity and real-world complexity.
- Problem-solving, higher-order thinking skills and deep understanding are emphasized.
- Exploration encourages students to seek knowledge independently and to manage the pursuit of their goals.
- Learners are provided with opportunities for apprenticeship learning in which there is an increasing complexity of tasks, skills and knowledge acquisition.
- Knowledge complexity is reflected in an emphasis on conceptual interrelatedness and interdisciplinary learning.
- Collaborative and cooperative learning exposes learners to alternative viewpoints.
- Assessment is authentic and interwoven into teaching.

Underlying Principles of the E⁶ Professional Development Model

The professional development model described in this article, which I have developed and coined the **E⁶ Learning Model**, is based on six principles: three that guide the curriculum and three that guide the learning process. The three curricular principles are engagement,

exchange of information, and empowerment. The three learning process principles are exploration, explanation, and exhibition.

Teachers are learners, so professional development must (1) engage teachers in personally and professionally relevant learning, (2) allow for extensive information exchange among participants, and (3) empower teachers to understand and use new technologies and strategies effectively in their classrooms. The professional development workshop, in turn, needs to be structured to (1) provide learners with opportunities and time to explore new technologies and teaching/learning strategies, (2) explain real-world data, inconsistencies, or problems using critical thinking and informed decision-making, and (3) exhibit their new knowledge gained through active, exploratory, inquiry-based learning in ways appropriate to the digital age in which they live and teach.

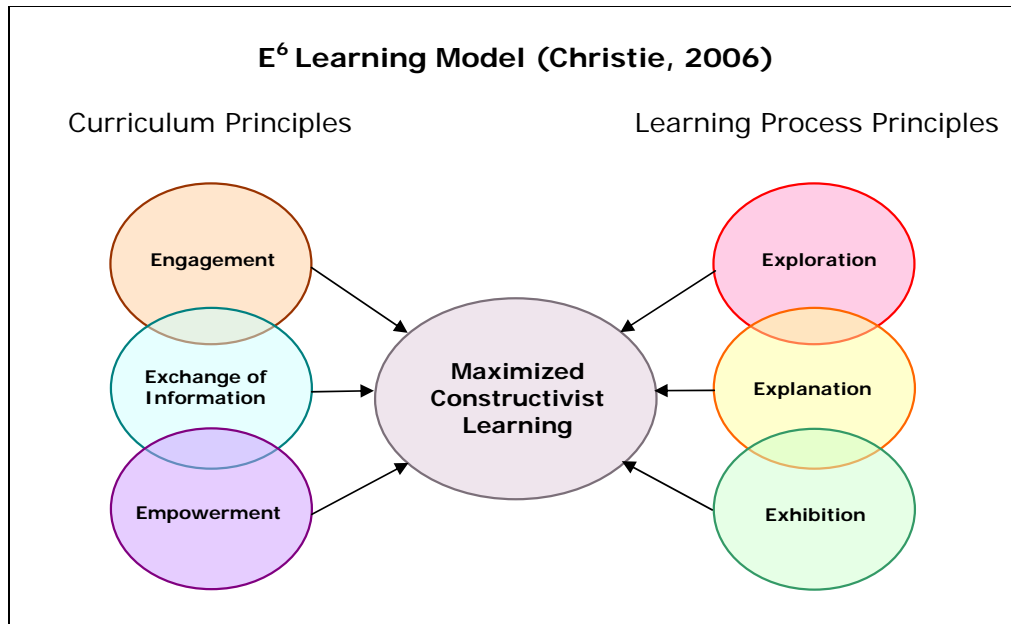


Figure 1. The E⁶ Learning Model

Application of the E⁶ Learning Model in Professional Development

In this section, I first describe how I apply the E⁶ Learning Model in GPS and Geocaching workshops for teachers; then, in the following section, I provide three specific examples of workshops I have offered practicing teachers that can be used equally well in K-12 settings. These three workshops were designed for different audiences and explore different knowledge realms.

GPS/Geocaching Workshop

Introduction

This professional development model has three overarching goals: (1) learn how to use GPS receivers, (2) learn to geocache, gather real-world data, and problem-solve authentic and personally meaningful challenges or inconsistencies, and (3) explore new ideas in any curricular area relevant to professional development or K-12 education.

Participating in a geocache activity helps learners understand the features and capability of GPS receivers. Through a hands-on workshop, teachers learn how to use GPS units, digital data, and online resources that support these technologies. By gathering and using authentic data, workshop participants (1) engage in the scientific process, (2) problem solve as needed to explore the options on their GPS units and find their geocaches, (3) collaborate with other learners to explore and explain the world around them, and (4) exhibit how these new technologies can be

used effectively in their own classrooms. Finally, learners explore a new knowledge realm relevant to their own professional development or their K-12 curriculum.

All workshops use a learn-by-doing, constructivist approach to ensure that participants are actively engaged, challenged to learn and integrate new concepts, working collaboratively with other participants, learning from their mistakes, and applying their new understandings/skills to their own teaching/learning situations.

Purpose and Goals

Upon completion of GPS/Geocaching Workshop, participants will be able to:

- Understand the GPS coordinate system
- Understand the GPS keypad
- Increase understanding of mapping systems
- Increase understanding of mathematical principles of angles, distances, triangulation, and direction
- Use GPS units to navigate to a specified location
- Understand the concept of direction and distance as represented on GPS units
- Understand the principles of geocaching
- Plan and implement curricular units that utilize GPS units and geocaching
- Use GPS units to locate caches hidden on or near the workshop locale
- Use GoogleEarth™ to provide data about locations of geocaches locally and globally
- Conduct field work by collecting authentic data
- Use real-world data to encourage higher order thinking skills in K-12 or university students
- Problem solve when GPS units provide conflicting or confusing data
- Problem solve when geocaches are not readily found

Time Frame

Three hours: one 3-hour session, or two 1.5-hour sessions

- Workshop Overview and Goals – 5 minutes
- Forming Teams and Assigning Roles – 10 minutes
- Exploring GPS Units – 15 minutes
- Geocaching – 45 minutes
- Discussing the GPS Exploration and Geocaching Experience - 15 minutes
- Discussing the Geocache Contents - 30 minutes
- Discussing Best Practices for GPS and Geocaching - 30 minutes
- Reviewing Online Resources – 15 minutes
- Applying New Skills to Individual Professional Responsibilities – 15 minutes

Prerequisite Skills

- Basic computer skills
- Openness to exploration

Materials Required

The workshop leader provides the following materials:

- GPS Receivers
- Geocaches (usually small, waterproof plastic box containing clues that help participants understand new concepts in any curricular area)
- Examples of curricular units and lessons plans that use GPS units and geocaching

- An extensive Web site of online resources on using GPS receivers and geocaching

Assessment

No external, multiple-choice test is needed to assess student success. Instead, evidence of student success comes through observation. The workshop leader continually monitors whether students are learning new concepts and skills based upon participants' behaviors using the GPS units while searching for geocaches. The workshop leader adjusts her instructional techniques, pace of instruction, and need for individualized instruction based on these observations. Further evidence of student success will be participants' level of interest in using GPS units and geocaching in their own classrooms, their professional development, and their personal lives at the conclusion of the workshop.

Specific Applications of the E⁶ Learning Model in K-12 Settings

In this section, I describe three workshops/lessons that use GPS receivers and geocaching; each focuses on a specific curricular area and is designed for a specific audience. *Workshop A* is for teachers and provides opportunities to explore ways to create constructivist learning environments. *Workshop B* is for middle school students and provides opportunities to sort, categorize, and graph a number of related objects (such as paper clips of various colors and sizes). *Workshop C* is for students, teachers, parents, or community members. It provides opportunities to learn about GPS, GPS receivers, and geocaching.

Workshop A: Constructivist Learning Workshop for Teachers

Purpose and Goals

During this session, participants will work in teams to complete an engaging and interactive geocaching activity in an outdoor location. They will use GPS units to locate hidden caches that provide clues to the central principles of constructivist learning. After discussing what they have learned from this problem-based activity, they will discuss ways that constructivist learning environments can help create active, reflective, student-centered learning that is socially relevant and personally meaningful to learners. This workshop is extended by the facilitator's Web site [<http://www.west.asu.edu/achristie/wakonse>].

Description of Geocache Contents

Cache	Team	Constructivist Principles	Contents
1	Green	Learning takes time	Tortoise, hare, watch, hourglass
2	Green	Learning incorporates prior knowledge	Building blocks
3	Green	Learning uses multiple intelligences	Representation of each (example: guitar for musical)
4	Blue	Learning is a process requiring tools/scaffolding	Tools, light bulb
5	Blue	Learning is global	Globe, circular bracelet, 4-port hub
6	Blue	We learn through our mistakes	Eraser, bumpy ball, white-out
7	Yellow	Learning is social and interactive	Helping Hands earrings, silly putty

8	Yellow	Learning embraces many perspectives	Box of crayons
9	Yellow	We learn through discovery/problem solving	Flashing ball, blocks, handheld puzzle
10	Red	Learning is collaborative	Glue, button with three people holding hands
11	Red	Learning is hands-on	Hand, glove
12	Red	Learning is reflective	Loon reflection, crystal

<i>Roles for Team Members</i>		
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Team Member A	Recorder	Records search process and discussion
Team Member B	Reporter	Reports on search process and discussion
Team Member C	Monitor	Monitors times and turns with GPS units
Team Member D	Photographer	Photographs group in action (inside and outside)

<i>Topics for Discussion</i>

Since the role of the teacher in constructivist learning environments is that of coach or facilitator, it is important that the teacher engage in extensive planning of this hands-on learning activity. Gathering meaningful and representative items to serve as "clues" that will stimulate thinking and discussion among students is vitally important to the success of this workshop. The two graphics below (created with Inspiration™) show what the students found in each cache (circled in red) and ideas students generated about constructivist learning after discussing each of the "clues" found in the 12 geocaches.



Figure 2. Principles of Constructivist Learning: Caches 1-6

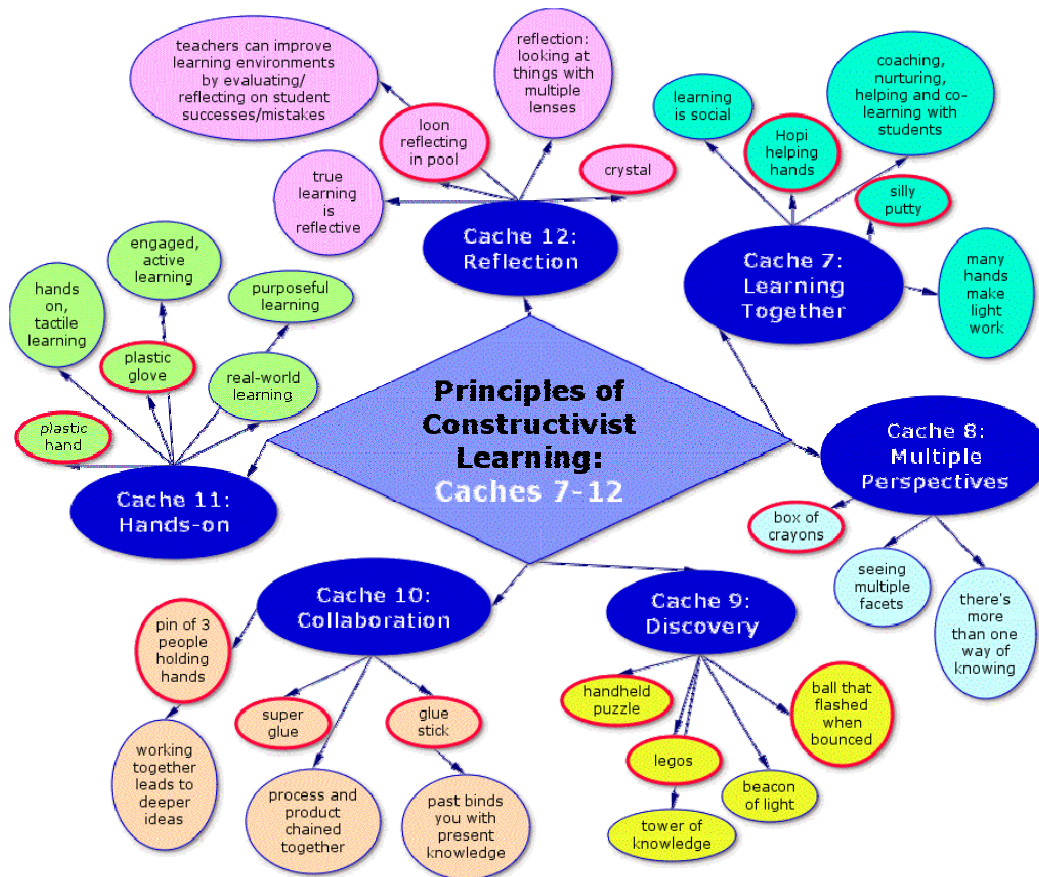


Figure 3. Principles of Constructivist Learning: Caches 7-12

Workshop B: Classifying, Sorting and Graphing Workshop for K-12 Students

Purpose and Goals

Teams of students will use GPS units to locate geocaches that their instructor has hidden around their school campus. Students will return to the classroom with the recovered geocaches, examine and discuss the contents of the geocaches, determine a number of possible ways to categorize the contents of each geocache, and then use Excel™ to create spreadsheets and graphs that represent the categorized data. The contents of each geocache can be sorted in two or more ways.

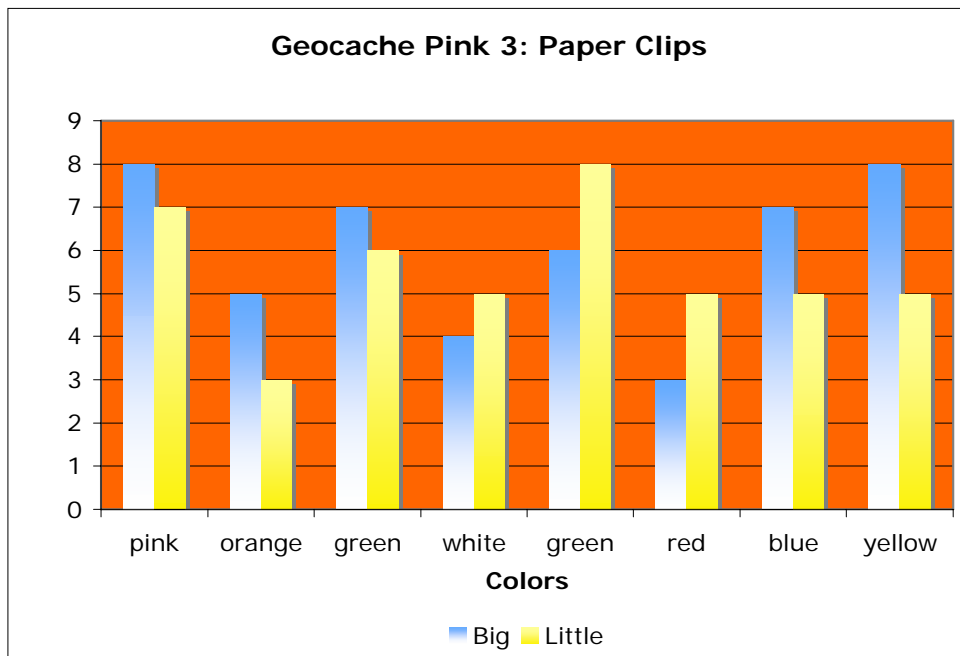
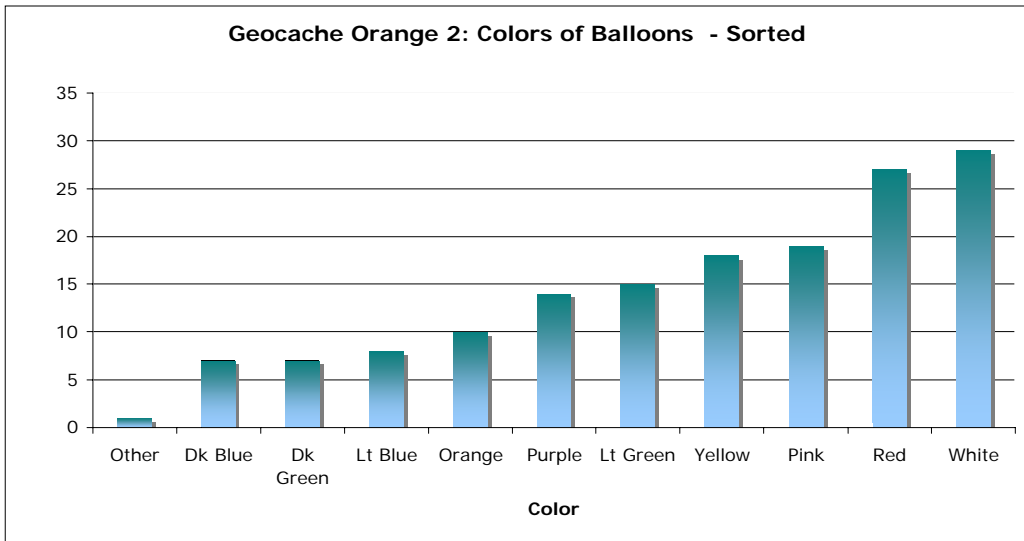
Photo of Representative Geocaches for This Workshop

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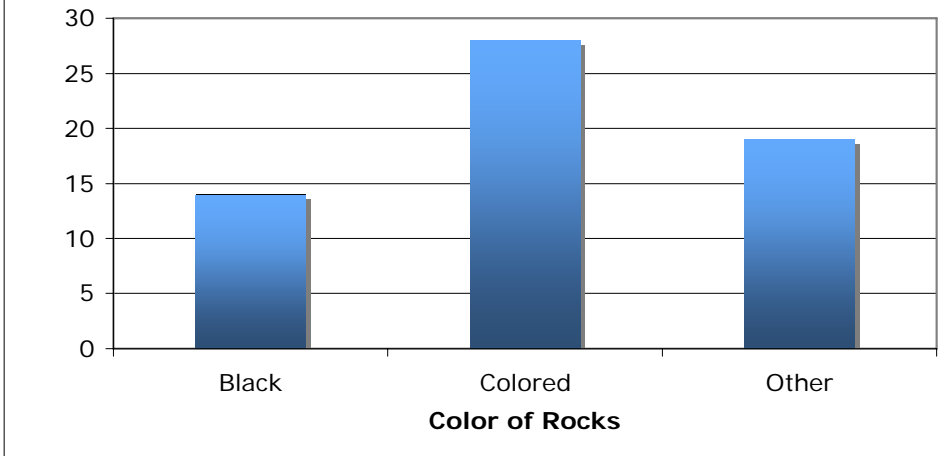
Geocache Contents (Pictures at <http://www.west.asu.edu/achristie/548/GCsort/>)

Cache No.	Cache Label	Team	Contents
0	Practice	All	Black and Red Checker Pieces Black and Ivory Chess Pieces
1	O-1	Orange	Wooden building blocks in 4 colors & 6 shapes (shown above)
2	O-2	Orange	Balloons in many colors and sizes (shown above)
3	O-3	Orange	Metal nails of various functions and lengths
4	P-1	Pink	Multicolored zip ties of two sizes
5	P-2	Pink	Multicolored, multi-textured hair bands
6	P-3	Pink	Paper clips in 8 colors and 2 sizes
7	B-1	Blue	Polished stones in black, brown, tan, cream, etc.
8	B-2	Blue	Plastic numbers in six colors
9	B-3	Blue	Wooden sticks in two colors and two sizes
10	Y-1	Yellow	Jigsaw puzzle pieces of various shapes/sizes
11	Y-2	Yellow	Cardboard smiley faces in six colors
12	Y-3	Yellow	Erasers of various colors and shapes

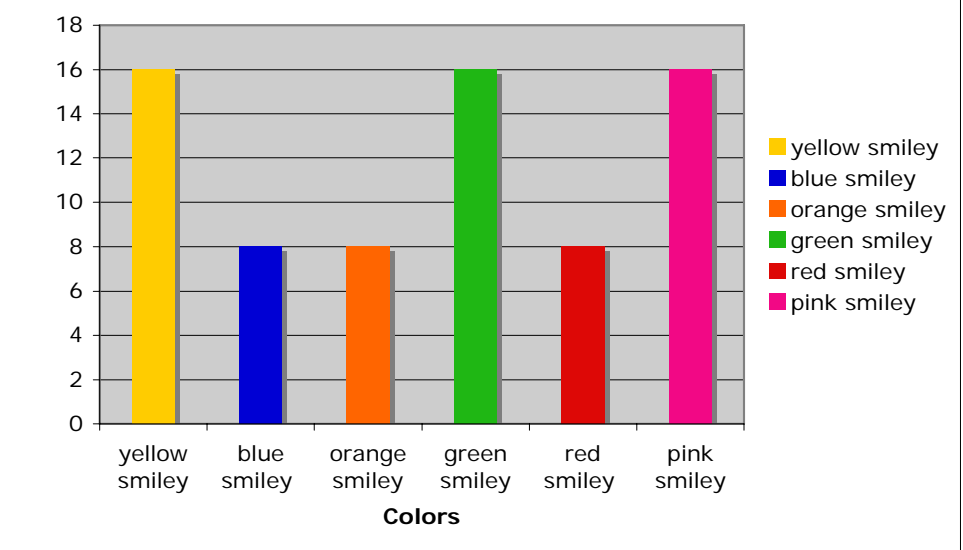
Figures 4-9. Representative graphs of sorted and categorized geocache contents

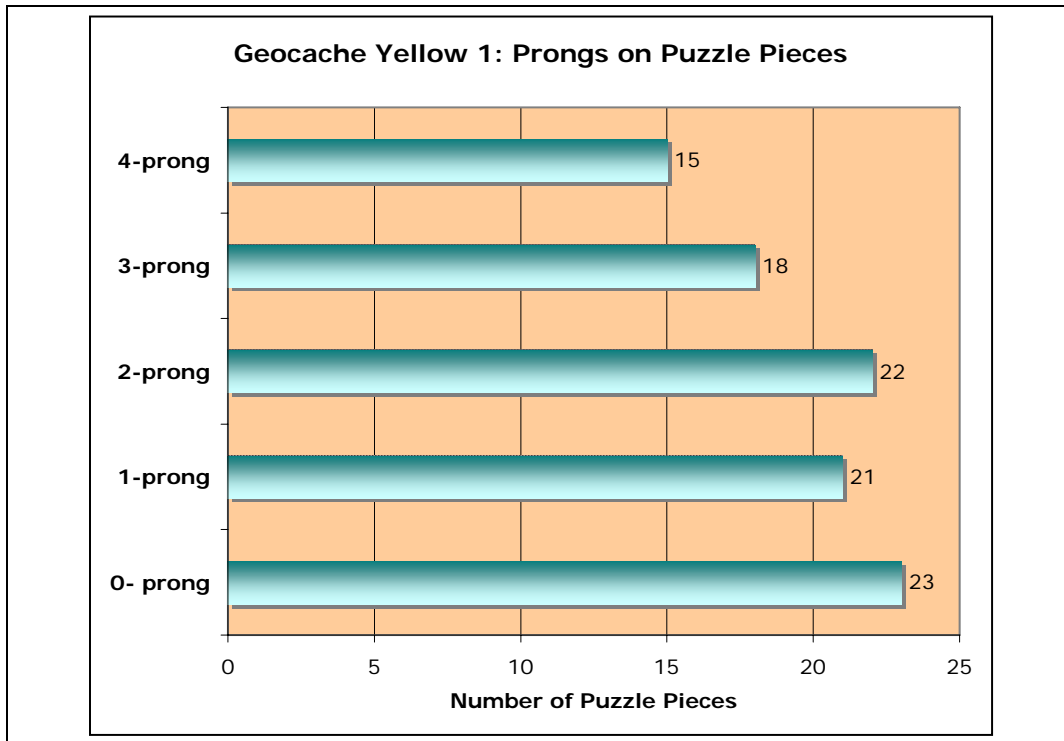


Geocache Blue 1: Multicolored Rocks



Geocache Yellow 2: Smiley Face Colors





Workshop C: Global Positioning System Workshop for Teachers, K-12 Students, Parents, or Community Members

Purpose and Goals

The purpose of this two-hour, hands-on workshop is to familiarize participants with the history of the international GPS, how GPS receivers work, who uses GPS receivers, tips on purchasing GPS receivers, and the growing worldwide phenomenon of geocaching. Students will learn by doing, using GPS receivers to locate geocaches that contain clues about each of the workshop topics. After finding their geocaches, each team will discuss their clues and decide how best to share this information with other teams. Sharing places each team in the role of expert and allows all teams to learn from each other.

Geocache Contents

Prior to this workshop, I created and hid 15 geocaches. Each geocache contained written clues on five topics: the history of GPS, how GPS works, who uses GPS, purchasing GPS receivers, and geocaching. The clues for each topic are listed below and at [<http://www.west.asu.edu/achristie/gps-gc/clues.htm>]:

History of GPS

- The GPS is a \$12 billion system of 24 satellites (plus a few spares) deployed and maintained by the U.S. Department of Defense.
- Selective Availability, which made the civil use of GPS less accurate than the military GPS, was turned off on May 1, 2000. Thus, the inexpensive GPS receivers available to civilians are as accurate as those used by the military today.

- Deployment of the satellites began in 1978, and the system became fully operational (uninterrupted global coverage) in 1995.
- Currently, there are millions of civilian users of GPS and GPS receivers worldwide.
- Although the cost of maintaining the system is approximately US \$400 million per year, including the replacement of aging satellites, GPS is available for free use in civilian applications as a public good.
- In late 2005, the first in a series of next-generation GPS satellites was added to the constellation, offering several new capabilities, including a second civilian GPS signal called L2C for enhanced accuracy and reliability.

How GPS Works

- GPS provides satellite signals that can be processed in a GPS receiver, enabling the receiver to compute one's position on the face of the earth (often indicated in terms of latitude and longitude).
- The GPS device receives data from the closest satellites, triangulating data to determine the unit's exact location (typically in latitude and longitude), elevation, speed, and time.
- Each GPS satellite passes around the earth twice in a 24-hour period at an altitude of about 12,500 miles. The satellites continuously broadcast position and time data to users throughout the world.
- Four GPS satellite signals are used to compute positions in three dimensions, so your altitude is also indicated on your GPS receiver.
- Each satellite contains a computer, an atomic clock, and a radio. The satellite continually broadcasts its changing position and time. Once a day, each satellite checks its own sense of time and position and makes minor corrections as needed.
- The location accuracy of a GPS signal as received by a GPS receiver is anywhere from 1 to 100 meters depending on the type of GPS receiver used.

Who Uses GPS and GPS Receivers

- GPS receivers are used in cars, boats, airplanes, and even in cellular phones. Most airlines allow passenger use of GPS units on their flights, except during landing and take-off when other electronic devices are also restricted.
- Handheld GPS receivers are carried by hikers, land surveyors, scientists, emergency personnel, medical evacuation helicopters, mapmakers, and others who need to know where they are.
- The US Military is a primary user of GPS. GPS allows accurate targeting of various military weapons including cruise missiles and precision-guided munitions. US Military personnel also use GPS in ground operations.
- Handheld GPS receivers are carried by mountain climbers and hang glider pilots. The system can be used to automate harvesters, mine trucks, tractors and other large agricultural machines, and other vehicles.
- Examples of GPS-based services are MapQuest Mobile and TomTom digital maps.
- GPS equipment is available for the visually impaired.

GPS Receivers

- Hand-held GPS receivers cost \$90 - \$1,000 and vary according to number of features and sophistication of features.

- Major Brands of Handheld GPS Receivers
 - Garmin
 - Magellan
 - Lowrance
- Major Brands of Auto GPS Receivers
 - Garmin
 - Magellan
 - TomTom
 - NavMan
 - Lowrance
- What GPS Receivers Tell You
 - How far you've traveled (odometer)
 - How long you've been traveling
 - Your current speed (speedometer)
 - Your average speed
 - A "bread crumb" trail showing you exactly where you have traveled on the map
 - The estimated time of arrival at your destination at your current speed
- Most GPS receivers are easy to setup and operate. There are different ways to input numbers and letters into your GPS unit. Most units use arrows or buttons to move between functions and screens. Others have actual alphanumeric keys, like your phone, for ease in entering names and numbers.
- GPS Receiver Features: Satellite Status, Menu, Position, Set Up Options, Compass, Navigation, Waypoint (marks a location), Distance to Location, Time, Sun and Moon Phases, Interface with maps and computer software, and more.

Geocaching

- Recreational applications include location-based games like Geocaching. Geocaching involves using a hand-held GPS unit to travel to a specific longitude and latitude to search for objects hidden by other geocachers.
- A geocacher places a waterproof container, containing a log book (with pen or pencil) and trinkets or some sort of treasures, then note the cache's coordinates. These coordinates, along with other details of the location, are posted on a website for other geocachers.
- Geocachers obtain cache coordinates from the Internet and seek out a cache using their GPS handheld receivers. The finding geocachers record their exploits in the logbook and online.
- Geocachers are free to take objects from the cache in exchange for leaving something of similar or higher value, so there is treasure for the next person to find. Typical cache treasures aren't high in monetary value but may hold intrinsic value to the finder.
- Geocaches can range in size from "microcaches," too small to hold anything more than a tiny paper log, to those placed in five-gallon buckets or even larger containers. Many are in Tupperware™ containers or ammo boxes.
- Geocaching rules are very simple:
 - Take something from the cache.
 - Leave something in the cache.
 - Place nothing dangerous in a cache.
 - Record your visit in the logbook and online.
 - Respect the environment and others.

Comments from Workshop Participants

In this section, I provide verbal comments on workshop participants' experiences as well as graphic summaries of student responses to the GPS/Geocaching Workshops. Overall, students (adult learners) knew little about GPS receivers or geocaching prior to the workshops, but were eager to learn about new technologies that their students (and their families) might be using now and in the future. They found the workshops to be engaging, empowering, enlightening, energizing, personally meaningful, and relevant for use in K-12 classrooms.

When queried about their experiences with GPS receivers and geocaching to find clues about a specific curricular topic, students commented on a variety of aspects of the workshop. The following are representative comments:

Hands-on nature of the experience

"A great hands-on learning experience. I appreciated being able to participate in the activity instead of just talking about it."

"I liked being able to get outdoors and actually use a new technology to accomplish a goal."

"I had never worked with a GPS, but we were able to quickly learn by doing and then find all our caches."

Collaborative nature of the experience

"Working together as a group to figure out a solution to a problem was the key to our success."

"It gave me an opportunity to work with and get to know some classmates and have a good experience with them."

"I had never used these devices so it was nice to have a security blanket in the form of other people to help."

"I especially like the conversations and problem-solving skills our group developed during this activity."

Engaging nature of the experience

"The best part of geocaching is the thrill of finding the 'prize' and figuring out what it means and how it relates to clues other groups find."

"What I liked most about geocaching was the spirit of mystery. Where is the cache? What is inside the cache?"

"It was fun trying to find the caches at the coordinates in the GPS. I like trying to solve mysteries, and it was like a big mystery."

"The most memorable moment was when I was first to find the cache. Even though it was not a race, I can see my students being as vigorous about it as I was."

Thought provoking nature of the experience

"I believe that geocaching is a grand way to incorporate technology, physical activity, and logical reasoning."

"Geocaching was an exciting activity that sparked thought-provoking reasoning in an unconventional way."

*Suggestions for improvements to the workshop**Need for improved student-to-GPS receiver ratio:*

"I would have like to have had more trial and error time with the GPS unit to construct my own learning."

"There were too many people sharing one GPS unit. I would have been happiest having one entirely for myself."

"I would have liked to have had more opportunity to actually use the GPS myself."

Technical difficulties

"The microwave tower and three-story buildings messed up our GPS and distorted our coordinates."

"Sudden failure in technology (GPS units) was a hindrance, but it turned out to be a springboard for our learning."

Participants also identified ways to incorporate GPS and geocaching into K-12 classrooms. Their suggestions include the following:

- Using this model to introduce content in ANY curricular area
- Categorizing and graphing items found in geocaches
- Identifying and establishing "observation sites" to look at trees, animals, soil, etc.
- Having students from other classes go to those spots and compare observations with those from their own site.
- Improving students' mapping skills
- Teaching coordinates and cardinal directions
- Teaching geography and location concepts
- Teaching collaboration and team building skills
- Incorporate writing prompt into the lesson to describe the students' experiences
- Teaching higher level thinking skills
- Incorporating technology into social studies, science, or math curricula
- Using GPS units as tools with limitations, not as failsafe pieces of technology

The graphic below (created with Inspiration™), which the workshop participants entitled *What We Learned About GPSs and Geocaching*, interestingly, does not comment on any specifics of using GPS technology; instead, it focuses on the learning process, zeroing in on five areas participants found most important: collaboration, sense of excitement and engagement, mistakes, discovery learning, and teacher considerations.



Figure 10. Types of learning identified by participants

Applying the Model in Middle School Classrooms

This hands-on, learn-by-doing model of professional development is equally applicable in middle school classrooms. Once teachers have experienced this model, and been in the role of learners working with other learners to solve problems, they can apply this model in their own classrooms. Teachers will need to modify the activity to align with specific state and local standards and grade level or developmental levels of their students, but the principles of using GPS receivers, geocaching, and discovery learning remain the same.

Basically, middle school teachers need to follow these steps in planning similar workshops for their classrooms:

- Buy, rent, or borrow GPS receivers (one for each group of 3-4 students). Schools or school districts may soon be purchasing class sets of GPS units for rotating use in classrooms.
- Decide on the curricular focus of the lesson/activity.
- Train a small group of students (from within the teacher's class or from a group of older students) on the use of GPS receivers. They will serve as mentors to each of the small groups of students participating in the lesson/activity. Schools or school districts may soon identify GPS mentors who can help in any classroom.

- Gather objects or create clues that will foster learning, raise curiosity, and encourage discussion about the curricular area chosen. (See the example of a sixth grade teacher's unit on US National Parks below.)
- Place these objects/clues in inexpensive plastic containers with an appropriate label. The label I use is pictured below.



OFFICIAL GEOCACHE

for Dr. Alice Christie's
ASU classes/seminars
Contact: 602-543-6338

PLEASE DO NOT DISTURB
www.west.asu.edu/achristie/gps-gc/

Cache Name:

- Hide these geocaches (with the help of mentors) at least 100 yards apart in the vicinity of your classrooms or other outdoor area to which the school has access.
- Record the coordinates of each geocache in GPS receivers.
- Introduce the lesson/activity to the class.
- Divide the class into groups (with no more than four per group).
- Provide brief instruction on the use of GPS receivers and specify how the mentors will help each group.
- Give each team a GPS receiver containing the coordinates of the geocaches they are assigned to find.
- Send each team and mentor outside to work collaboratively to find their assigned geocaches. Allow time for students to experiment, make mistakes, talk about these mistakes and how to overcome them, find their geocaches, and return to their classroom with their geocaches in hand.
- Facilitate small group discussions (within each team) about the contents of the geocaches and how these contribute to students' understanding of the curricular area.
- Facilitate a large group discussion (across all teams) about students' understanding of the curricular area.
- Facilitate a large group discussion about students' experiences with GPS and geocaching, including suggestions for future GPS/geocaching experiences.

A Family Vacation: Sample Sixth Grade Unit

The following example illustrates a sixth grade teacher's unit in which students plan a family vacation. Students, in groups of four, explore one of eight possible vacation destinations. In addition, students investigate expenses for travel and overnight accommodations. Finally, each group creates a brochure advertising their family vacation to share with other class members, other sixth grade classes, and their parents. Teachers can easily integrate numerous technologies, including a GPS/geocaching activity, into this cross-curricular unit.

The teacher decides to introduce students to eight vacation destinations through a GPS/geocaching activity. He or she chooses eight US National Parks [<http://www.nps.gov/>] because his or her standards-based social studies curriculum specifies that students understand the National Park System in the United States. The teacher then locates/creates clues to be placed in each of the geocache boxes. Clues can take many forms including:

- plastic, metal, paper, or wooden objects that suggest ideas about each team's topic
- pictures from magazines, newspapers, the Internet, vacations, advertisements, etc.
- sketches, drawings, or any kind of art work
- verbal clues written on tagboard
- maps, graphs, satellite images, iTunes, etc.
- online videos (see <http://www.discovery.com/googleearth/> for an excellent collection of videos on the National Parks)

Teams of students locate the geocaches and then examine and discuss the contents of each geocache to increase their understanding of key curricular ideas. The charts below summarize possible destinations and clues for each sixth grade team participating in this GPS/geocaching lesson/activity on US National Parks:

Team	Destination	Location
Red	Yosemite	Sierra Nevada, CA
Blue	Yellowstone	ID,MT,WY
Green	Grand Canyon	Grand Canyon, AZ
Yellow	Glacier	Northwest Montana, MT
Orange	Mount Rainier	Ashford, Enumclaw, Packwood, Wilkeson, WA
Brown	Everglades	Miami, Naples, and Homestead, FL
Black	Badlands	Southwestern, SD
White	Bryce Canyon	Bryce Canyon, UT

Yosemite National Park: Sierra Nevada, CA



- Yosemite is one of the first wilderness parks in the United States.
- It is best known for its waterfalls.
- It measures nearly 1,200 square miles (747,956 acres) that includes deep valleys, meadows, and ancient giant sequoias.
- 95% of Yosemite is designated wilderness.
- Yosemite receives most of its precipitation in the months of January, February, March.
- Clouds can build up during the summer to produce spectacular thunderstorm activity.
- Its highest peak is Mt. Lyell, 13,114 feet
- Park Visitation has grown from 42 visitors in 1855 to over 4 million in 1995.

Yellowstone National Park: ID,MT,WY



- Established in 1872
- America's first national park
- Only park located in three states: Wyoming, Montana, and Idaho
- Home to much wildlife including grizzly bears, wolves, bison, buffalo and elk
- Home to the world's most extraordinary geysers and hot springs, including Old Faithful
- Most of the park is above 7,500 feet
- The 1988 fires affected 793,880 acres or 36 percent of the park.
- The largest 1988 fire, the North Fork Fire, started from a discarded cigarette, burning more than 410,000 acres

Grand Canyon National Park: Grand Canyon, AZ



- A great chasm carved over millennia through the rocks of the Colorado Plateau
- Achieved National Park status in 1919, three years after the creation of the National Park Service
- Park visitation: 44,000 in 1919, nearly five million annually now
- The South Rim of Grand Canyon averages 7000 feet (2134 m) above sea level and the North Rim is over 8000 feet (2438 m).
- North Rim is much less accessible than the South Rim as heavy snows close the road to the North Rim from late October to mid May of each year.
- The inner canyon is 277 miles long and includes everything below the rim and is seen mainly by hikers, mule riders, or river runners.
- Elk found within Grand Canyon National Park weigh as much as 1,000 pounds (450 kg).
- The oldest human artifacts found are nearly 12,000 years old and date to the Paleo-Indian period.
- Park in continuous use and occupation since that time

Glacier National Park: Northwest Montana, MT



- Established as the country's 10th national park in 1910
- Established as Waterton-Glacier International Peace Park in 1932
- Over 1 million acres including forests, meadows, mountains, and lakes
- Over 700 miles of trails for hikers that follow routes first used by trappers in the early 1800s
- If current trends continue, scientists have predicted that by the year 2030, there will be no more glaciers in Glacier National Park due to global climate change
- Number of glaciers: 37 named; all shrinking in size
- Largest glacier: Blackfoot Glacier - .7 sq. miles
- Number of lakes: 653, Acres of lakes: 27,023, Miles of shoreline: 392
- Largest lake: Lake McDonald (10 miles long; 6,680 wide; 440' deep; 6823 acres)
- Land: 1,013,594 acres with 500+ in private ownership or 1,583 square miles
- Acres of wilderness: 963,155, or 1,489.3 square miles

Mount Rainier National Park: Ashford, Enumclaw, Packwood, Wilkeson, WA



- Encompasses 235,625 acres on the west side of the Cascade Range
- Located about 100 kilometers (50 miles) southeast of Seattle, WA
- Approximately 97 percent wilderness and 3 percent National Historic Landmark
- Receives approximately 2 million visitors per year
- Mount Rainier is an active volcano that last erupted approximately 150 years ago
- The 14,410' Mount Rainier is the most prominent peak in the Cascade Range, standing nearly three miles higher than the lowlands
- Fay Fuller, a schoolteacher from Yelm, Washington, was first woman to climb to top of the mountain in 1890; Susan Longmire (age 13) followed her in 1891.
- Currently 10,000 men and women attempt to climb to the summit of Mount Rainier each year, about half are successful
- The park contains 26 named glaciers across 9 major watersheds, with 382 lakes and 470 rivers and streams and over 3,000 acres of other wetland types
- Carbon Glacier (in the northwest corner of the park) is the lowest in elevation of any glacier in the lower 48 states at 3500'
- The Carbon River Valley has mild temperatures and receives about 70 - 90 inches of rain a year, which has created an inland temperate rainforest

Everglades National Park: Miami, Naples, and Homestead, FL



- Is the largest subtropical wilderness in the United States
- Is a low, flat plain shaped by the action of water and weather. In summer (wet season) it is a wide, grassy river, in winter (dry season) it is a dry grassland
- Is technically a river, flowing southwesterly at the rate of a quarter mile per day
- Is designated an International Biosphere Reserve, a World Heritage Site, and a Wetland of International Importance
- Has an average rainfall of 60 inches (152 cm) per year. The rainy season is June – October.
- Boasts 156 miles (251 km) of canoe/kayak and walking trails
- Contains 27 species of snakes, only four are venomous/poisonous: cottonmouth, diamondback rattlesnake, dusky pygmy Rattlesnake, and coral snake
- Is home to rare and endangered species, such as American crocodiles, Florida panthers, West Indian manatee, alligator, bobcats, mosquitoes, American White Pelicans, tree snails, and turkey vultures
- Has more insects than any other group of animals

Badlands National Park: Southwestern, SD



- Badlands was originally proclaimed a National Monument in 1939 and became a National Park in 1978.
- The Badlands National Park is located within what is called the White River Badlands.
- Badlands earned its name by being difficult to travel through because of the rugged terrain and lack of water.
- Landscape within the park erodes at a rate of about 1 inch per year.
- Badlands National Park is 381 square miles or 244,000 acres in area.
- The highest point in the Park, Pinnacles, is 3247 feet or 1009 meters
- The Park contains the world's richest fossil beds, dating 37-28 million years old.
- Bison, bighorn sheep, endangered black-footed ferrets, and swift fox inhabit one

- of the largest, protected mixed-grass prairies in the United States
- The Badlands climate is variable and unpredictable, with temperatures ranging from -40 F to 116 F. The summers are hot and dry with occasional violent thunderstorms. Winters are typically cold with 12 to 24 inches of total snowfall. Average annual precipitation is 16 inches
- Does not contain any dinosaur fossils, but does have fossils of ancestors of the modern day rhinoceros, horse, pig, and cat as well as early birds, reptiles, and invertebrates

Bryce Canyon National Park: Bryce Canyon, UT



- Bryce Canyon is a small (56.2 square miles) national park in southwestern Utah.
- Named after the Mormon Pioneer Ebenezer Bryce, Bryce Canyon became a national park in 1924.
- Bryce Canyon, famous for its worldly unique geology, consists of a series of horseshoe-shaped amphitheatres and hoodoos: spire or odd-shaped rocks left standing by the forces of erosion.
- Hoodoos are formed when ice and rainwater wear away the weak limestone common to the area.
- Three distinct climatic zones due to 2000 feet (650 m) change of elevation: spruce/fir forest, Ponderosa Pine forest, and Pinyon Pine/Juniper forest.
- Rim elevation is between 8,000 to 9,100 feet.
- Wildlife includes mule deer, Utah prairie dogs, chipmunks, pronghorn (antelope), gray fox, ravens, Steller's jays, Clark's nutcrackers, and short-horned lizards.
- The Park is home to three endanger species: Utah Prairie Dog, California condor, and the Southwestern Willow Flycatcher.
- In most rural areas of the United States, 2500 stars can be seen on a clear night. At Bryce Canyon, 7500 stars can be seen.
- Bryce has high biodiversity: over 100 species of birds, dozens of mammals, and more than a thousand plant species

Online Resources

There are numerous online resources that explain and support the use of GPS units and geocaching in education. These are divided into a number of categories for easy references for teachers wishing to extend their understanding of using GPS units, geocaching, or GoogleEarth™ in their classrooms. Links to relevant sites are listed below:

- **Comprehensive sites** on using GPS and geocaching in Education:
 - The author's [GPS and Geocaching Site](#) (extensive list by topics)
 - EduScape:
 - [Geocaching With Kids: Activate the Learning Environment](#)
 - [GPS and GIS in the Classroom](#)
 - [GPS & Place-based Learning](#)
 - Harvard-Smithsonian Center Space Geodesy's [Using GPS in the Classroom](#)
- **Articles about teachers** using GPS receivers and/or geocaching:
 - [Height Modernization and GPS take off in the Classroom](#)
 - [Simulation games aim to spark real-world learning](#)
- **Professional development for teachers** on GPS receivers and/or geocaching:
 - [Middle school teachers to take part in science program at Illinois](#)
 - [Teachers Get Tech-Savvy: Rural Educators Learn About New Technologies](#)
- **Articles about K-12 students** using GPS receivers:
 - [Horace Mann Middle School GPS Event](#) (scroll down a bit)
 - [Virtual Argonauts](#) (Edutopia)
 - [From Brain-Based Research to Powerful Learning](#) (Edutopia)
 - [A Change in Attitude](#) (Edutopia)
- **Articles on using GPS and geocaching in education:**
 - Subaru's Drive Magazine: [Geocaching – High Tech Hide and Seek](#)
 - Juicy Geography: [GPS for Geography Teachers](#)
 - Juicy Geography: [GPS in School](#)
- **Articles on GoogleEarth™:**
 - [The Good Earth](#)
 - Juicy Geography: [GoogleEarth™ in the Classroom](#)
 - Tutorial on [How to Create a GoogleEarth™ Virtual Tour](#)
 - [GoogleEarth™ Resources for Geography Teachers](#)
 - [GoogleEarth™ Lessons: An Educational Resource for Teachers](#)

Photo Galleries

I use GPS receivers and geocaching activities in my graduate classes at Arizona State University. To view any of my classes in action, click on a link below and then scroll through the photo gallery. To view the larger version of any photo, simply double-click on that photo.

- GPS/Geocaching Workshop on Constructivist Learning:
 - [Group 1](#)
 - [Group 2](#)
 - [Group 3](#)
 - [Group 4](#)

- GPS/Geocaching Workshop on [Sorting and Categorizing](#):
- [Sorting and Categorizing Extension Activity](#)

I also am an active geocacher and user of GPS receivers for hiking and exploring the world around me. I love introducing students, friends, relatives, and even total strangers to the fun, challenging, and exciting opportunities that GPS units and geocaching offer. [Dr. Christie Geocaching](#).

Podcast

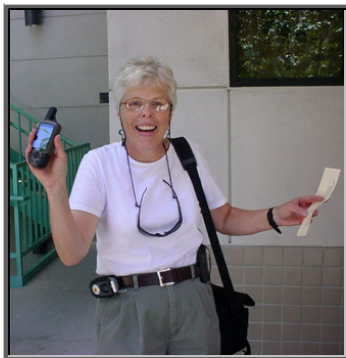
Conclusion

Teachers can create technology-rich, constructivist learning environments that engage students in student-centered, personally meaningful, authentic, and collaborative learning that is inquiry-based, requires informed decision-making, views mistakes as opportunities for growth, and values information exchange among all learners. One plausible way to achieve this goal is to use GPS receivers and geocaching in K-12 classrooms. This article provided a theoretical rationale (E⁶ Learning Model) for such an approach. It also provided specific examples of classroom activities that incorporate GPS units and geocaching, specific steps a teacher should take to create similar curricular lessons, as well as examples of clues teachers could include in geocaches to increase student understanding of any curricular area. Finally, it provided numerous online resources (and a podcast) that provide teachers with additional ideas for making GPS receivers and geocaching integral tools in their engaging, empowering and enlightening classrooms.

Author Background

Dr. Alice Christie is an exemplary teacher with forty years of experience in both K-12 and university classrooms. She is a frequent presenter and keynote speaker at regional, national and international educational technology conferences. She was recently named as one of four Arizona State University President's Professors.

Alice is an experienced GPS user and geocacher. She has taught numerous GPS and geocaching workshops that her participants describe as highly effective, instructional, and applicable in K-12 and university classrooms. She has located geocaches across the country and has hidden many geocaches in Arizona. She finds each geocaching experience to be a learning experience.



Dr. Alice Christie will be presenting two three-hour workshops on using GPS receivers and geocaching in K-12 classrooms at the National Educational Computing Conference (NECC) [<http://center.uoregon.edu/ISTE/NECC2007/>] in Atlanta, GA on Monday, June 25, 2007.

References

- Honebein, P. C. (1996). Seven goals for the design of constructivist learning environments. In B. G. Wilson (Ed.), *Constructivist learning environments: Case studies in instructional design* (pp. 17-24). Englewood Cliffs, NJ: Educational Technology Publications.
- ISTE (2006). *All children must be ready for a different world*. Retrieved December 1, 2006 from <http://cnets.iste.org/intro2.html>
- Jonassen, D. H. (1991). Objectivism versus constructivism: Do we need a new philosophical paradigm. *Educational Technology Research and Development*, 39(3), 5-14.
- Jonassen, D. H. (1994). Thinking technology: Context is everything. *Educational Technology*, 34(4), 34-37.
- Murphy, E. (1997). Constructivism: From philosophy to practice (Report No. SP 039 420). St. John's, NL Canada: Centre for Distance Learning and Innovation. (ERIC Document Reproduction Service No. ED444966). Retrieved December 1, 2006 from http://eric.ed.gov/ERICWebPortal/Home.portal?_nfpb=true&_pageLabel=RecordDetails&ERICExtSearch_SearchValue_0=ED444966&ERICExtSearch_SearchType_0=eric_accno&objectId=0900000b80124662
- von Glasersfeld, E. (1995). A constructivist approach to teaching. In L. Steffe & J. Gale (Eds.), *Constructivism in education* (pp. 3-16). Hillsdale, NJ: Lawrence Erlbaum.
- Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.
- Wilson, B. & Cole, P. (1991). A review of cognitive teaching models. *Educational Technology Research and Development*, 39(4), 47-64.