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Unlocking Thinking Through and About GPS

James E. Schwartz
St. John Fisher College, jschwartz@sjfc.edu

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Abstract
The article offers information about global positioning system (GPS) and geocaching which started when GPS satellite signals were opened to public in the U.S. in 2009.Topics discussed include the Small Footprints nature education trail in a college which consisted of seven outdoor learning stations on campus that is used through geocaching; benefits of using GPS in education and use of GPS to develop critical thinking skills.

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feature article

unlocking thinking through and about GPS

by James E. Schwartz

introduction

What can combine the challenge of a treasure hunt, the thrill of a walk in the woods, the excitement of a puzzle well-solved, *and* support learning of critical thinking skills? Learners and teachers in a small city in upstate New York are discovering that all of these elements and more are a part of the *Small Footprints* Nature Education Trail located at a local college. During a recent academic year, students and faculty worked together to construct a technologically-based learning experience that uses the natural environment on campus as a site for teaching critical thinking in the context of ecology and conservation. The unique thing about this nature "trail" is that it is entirely invisible! *Small Footprints* consists of seven outdoor learning stations on campus that users access through geocaching.

Geocaching began as a recreational pursuit that makes use of handheld GPS receivers, Internet-based locational data, and hidden "caches" that contain miscellaneous objects and information. Geocaching began in May, 2000, when the U.S. government "opened" GPS satellite signals to the public. Prior to this date, the Global Positioning System (GPS) was only available for military applications. The basic concept of geocaching is that a GPS receiver is programmed to identify a specific location on earth, known as a *waypoint*. At that location, geocachers can hide an object (a cache), and other geocachers can later use their GPS receivers to find the general location and then use problem-solving skills to locate the cache. *Small Footprints* is but one example of an educational use of geocaching. A growing body of literature documents many others.

Dixon (2007) describes educational activities built around the use of geocaching. One of the activities she describes is a trip to the zoo, in which a teacher marked a number of locations at the zoo as waypoints. Teachers constructed worksheets for the students to complete at each of these waypoints. One school used geocache sites on campus as a treasure hunt. One school used it as a team-building (problem-solving) experience for teachers. One summer camp uses geocaching by having students take digital photos at the waypoints and then construct edited video of their adventure. In one community, local historians set up waypoints in a local park, and students used them to learn and write about local history and geography (in the park). Some classes follow Travel Bugs[1] around the world from their classrooms (using geocaching.com).

potential educational benefits of teaching with GPS

Buck (2009) emphasizes the motivational and attitudinal benefits to students of using GPS-based learning activities. In one activity in Buck's (2009) study, students were given algebra problems to solve, the solutions to which became latitude and longitude coordinates to enter into a GPS-locating device. The device then led students to locations that contained further problems and clues to additional locations. A second activity in Buck's (2009) study required students to use GPS devices to determine latitude and longitude coordinates for specific campus locations and then plot and use those coordinates to complete various math problems. The math problems used in these activities employed skills that the students had already learned and on which they had already demonstrated a level of fluency.

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[1] A Travel Bug is an object that geocachers find in one cache and move to another cache, keeping an online log of its locations.

Buck (2009) reports on many different findings, one of which is that students enjoyed using GPS-based activities, and they enjoyed working outdoors. These findings are, most likely, generalizable to other students and other subject areas: GPS-based outdoor activities are enjoyable to many students. Buck notes that until students had a meaningful context for learning something as basic as cardinal compass directions, they paid little attention to the instruction provided. However, when students found that they needed specific information, such as where the cardinal directions were, they paid close attention to instruction in order to be able to solve the problem they cared about.

Anderson (2008) states that geocaching closely aligns with two National Educational Technology Standards for Students. These standards are as follows:

- **Communication and Collaboration:** Students use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others.
- **Critical Thinking, Problem Solving, and Decision Making:** Students use critical thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources.

teaching and understanding the Global Positioning System itself

A study of the functioning of the Global Positioning System itself is an ideal STEM context in which to develop critical thinking skills. Although the GPS is a complex, highly-technical system, students as young as Grade 5 have been able to gain a basic understanding of how the components work together to provide users with their geographic location on earth. "Where in the World are We?" is a Performance Task designed to give young people an understanding of how GPS works. In this Performance Task, there are four "explorations," the first of which helps students understand the deductive logic of trilateration. Using a 2-dimensional model of finding a location on a map, students come to realize that the knowledge of three distances to an unknown location overlap at one and only one specific point, thereby giving us certainty of that location on a map.

Figure 1. Finding our place through trilateration.

In the next exploration, students interact with a web-based interactive simulation of two runners to develop their understanding of the rate/time/distance relationship. This simulation allows students to freely experiment with various speeds and distances to observe the effects on the runners' times. This exploration gives students a conceptual building block that will eventually help them troubleshoot a malfunctioning GPS.

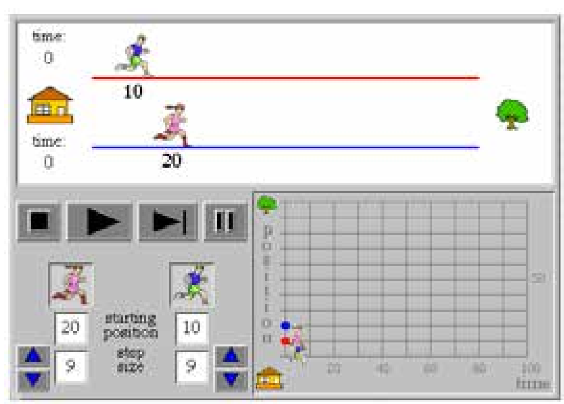


Figure 2. Exploring Rate x Time = Distance (http://www.nctm.org/standards/content.aspx?id=25037)

NASA's Data

The following data table is from one of the GPS receivers that has been leading people astray. The data table shows you all the information from all 24 satellites at a specific moment in time. Can you find out what is wrong?

Satellite Identification Information	Rate	Time (in seconds) A value of 0 indicates a satellite that is not available.	Distance (in miles)
Satellite #1	186K miles/second	0	xxxxx
Satellite #2	186K miles/second	0	xxxxx
Satellite #3	186K miles/second	0.002	3720
Satellite #4	186K miles/second	0	xxxxx
Satellite #5	186K miles/second	0	xxxxx
Satellite #6	186K miles/second	0	xxxxx
Satellite #7	186K miles/second	0.008	14880
Satellite #8	186K miles/second	0	xxxxx
Satellite #9	186K miles/second	0	xxxxx
Satellite #10	186K miles/second	0	xxxxx
Satellite #11	186K miles/second	0	xxxxx
Satellite #12	186K miles/second	0	xxxxx
Satellite #13	186K miles/second	0.007	13020

Figure 3. NASA's Data

Finally, students learn how communications between multiple satellites and a ground-based, handheld unit use the r x t = d relationship along with trilateration to lock in a location. Using the familiar swimming pool game of Marco Polo as an analogy, the exploration helps students understand how handheld GPS receivers compute distances to at least three GPS satellites.

In this Performance Task, students must examine (fictional) data that has been collected from a malfunction in the Global Positioning System, and they must use an understanding of the cross-cutting theme of *cause and effect* to diagnose and offer a repair strategy for this malfunctioning system. This activity is a wonderful implementation of *STL* Standard #10, "Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving" (ITEA/ITEEA, 2000/2002/2007, p. 210).

This Performance Task directly supports the development of the critical thinking skills of reasoning effectively, using systems thinking, making judgments and decisions, and solving problems. Students must learn enough about the system to identify where a failure is occurring and then craft a possible repair strategy that could be used to fix the problem. Students discover that the problem is that *all* of the distances calculated from *all* the available satellites are "off" by a power of ten. In this exercise, it is important for students to give close attention to place-value in order to uncover an error while examining large numbers. To help them solve the problem (locate the source of the erroneous data), students are given information that the "time" data are produced by a computer chip in the GPS receivers. Since the distances are computed using a constant rate and a receiver-generated time, the logical source of the problem is the computer chip that is calculating the times.

Students use their newly-acquired knowledge about the system and about the rate-time-distance relationship to call into question the functioning of the computer chip that calculates the times and uses the rate constant to produce the distance. Since students are told (in the simulation) that a single manufacturer produces all of these computer chips, that manufacturer may have produced a faulty chip, either in terms of the programmed constant for the rate or in terms of the method of recording the time of arrival of the signal. As they come to a solution for the problem, students not only gain a realistic problem-solving experience, but they also gain a basic understanding of how the Global Positioning System works. Students engage in cause-effect analysis, they analyze the function and structure of the system, and they use proportional reasoning in analyzing the mathematics.

Whether students are exploring the functioning of the Global Positioning System itself or engaging in geocaching activities, GPS offers great opportunities for education. Embedding new material in the context of real-world applications is an effective teaching strategy for developing critical thinking skills. Nearly all families today make use of GPS in a variety of ways, and a basic understanding of the system itself is now a beneficial and rewarding area of study.

references

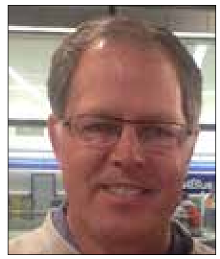
Anderson, M. (2008). Geocaching for fun and learning. *Multimedia and Internet@Schools, 15*(2), 32-35.

Buck, L. (2009). *The motivational effects of a GPS mapping project on student attitudes toward mathematics and mathematical achievement.* Ph.D. dissertation, The University of Alabama, United States – Alabama. Retrieved from Dissertations & Theses @ University of Alabama. (Publication No. AAT 3356452).

Dixon, A. (2007). Finding your way: GPS and geocaching. *Learning & Leading with Technology, 34*(8), 29-31.

International Technology Education Association (ITEA/ITEEA). (2000/2002/2007). *Standards for technological literacy: Content for the study of technology.* Reston, VA: Author.

National Research Council (NRC). (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas.* Washington, DC: National Academies Press.



James E. Schwartz, Ph.D. *is Associate Dean at the Ralph C. Wilson, Jr. School of Education and Professor, Inclusive Education at St. John Fisher College. He can be reached at jeschwartz@sjfc.edu.*

This is a refereed article.

Activity – continued from page 11.

items reflect the shapes of cellular organelles. The students will be provided an array of items, and they will make decisions about creating a model that represents the authentic shapes of animal cell parts. The instructor will purposefully assign the student lab pairs to make sure that they complement each other. The instructor will ensure the difficulty of the experience is appropriately challenging and not discouraging for each learner by closely monitoring all of the groups during the lab. The instructor will provide feedback to the students if he/she observes increasing student frustration.

The instructor will provide the learners with edible items that could match the shapes of eukaryotic cell parts. For example, a flat graham cracker may serve as the cell wall of a plant cell, but not for an animal cell, an Oreo cookie may represent a nucleus, icing may be cytoplasm, sprinkles may be ribosomes, twizzlers could be torn apart to create the cell membrane, Frito chips may be the golgi bodies, red hots may serve as lysosomes, etc.

c. Reflecting on Experience

Reflecting on the experience includes two parts:

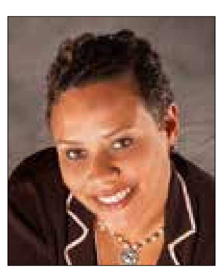
1. **Teacher facilitation.** The instructor will use verbal prompts and probing questions to the students if he/she observes the students choosing blatantly wrong items to build their cells.

2. **Community building.** After the students build their cell models, they will be displayed around the room. The students will be given the opportunity to critique their peers' models to see what decisions others made to build their cells as compared to their own decisions. The students will be instructed to defend their choices and critique their peers' decisions in a nonthreatening way that stimulates meaningful dialogue with a secure community of learners who are able to provide and receive constructive criticism. Therefore, at the conclusion of the activity, the students will walk around and view their classmates' edible cells and reflect upon what others chose, think about why they possibly chose the items, and what was learned in the lesson. The students will also reflect on ways to improve the experience or items that could be used in the future that would better represent the cell parts. The teacher will act as a facilitator to help the students verbalize their thinking process when building their cells and provide redirection as necessary.

references

BJ's Science. (n.d.). *Cell theory rap.* Retrieved from http://camillasenior.homestead.com/Cell_Theory__Rap_.pdf

Reigeluth, C. M. & Carr-Chellman, A.A. (2009). *Instructional design theories and models: Building a common knowledge base.* Routledge: New York.



Janice Underwood, PhD *teaches at Old Dominion University in Norfolk, VA in the Department of STEM Education and Professional Studies, where her research focus is culturally relevant teaching, particularly in science. For more information on this lesson, Janice can be reached at junderwo@odu.edu.*