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The Design of a Constructivist Learning Experience that uses GPS Technology

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Abstract: A constructivist learning experience using Global Positioning System (GPS) technology was conducted with second and third grade students in a public elementary school in Cupertino, California. The students made a map of their school by recording location information with handheld GPS devices and then graphing the data. The effort, performed by three classes of 20 pupils each, seemed to help students gain intuition about the abstract relationship between maps and the physical spaces that maps represent. The experience also seemed to help students grasp complex concepts such as the accuracy of their data, the scale of their maps, as well as the utility of using technology to perform data collection and analysis.

Introduction

This paper describes a constructivist learning project conducted with elementary age students in a public school setting. The project was designed to help the students develop their understanding of *maps* and *mapmaking* while also exposing them to important math and science concepts such as scale, graphing, dimensions, data collection, data accuracy, and group collaboration. The central technology for this effort was a low-cost, hand-held *Global Positioning System* (GPS) receiver. GPS is a technology for acquiring precise spatial locations (latitude and longitude) anywhere on earth. The receiver collects data from a network of orbiting satellites and uses that data to compute its global location in terms of accurate latitude and longitude values. The typical cost of such a device is between $100 and $300 making it an affordable resource for most primary school settings. These devices are often sold for hiking and camping activities so they are sufficiently rugged for classroom use.

Lesson Overview

The students were given a clear project goal – *to construct a scale map of their school campus.* Provided with handheld GPS receivers, the students were instructed to walk around the campus and record specific locations known as "waypoints." These waypoints are numerical coordinates (latitude, longitude) that have a spatial resolution to within just a few feet. By collecting a detailed set of waypoints, the students performed a "survey" of their campus, documenting the spatial layout of significant features. For example, students outlined the shape of each building, the playgrounds, the sporting fields, and the parking lots. To make the project more manageable, the students were asked to split the campus into smaller sections, each section assigned to a specific group of students. Students belonging to a given group would walk around their portion of the campus as a team, collecting the necessary data. Once the data was collected, each group took turns plotting their respective section of the campus on a single large piece of graph paper until a map of the entire school was produced.

The Setting: this lesson was conducted at Portal Elementary School, an alternative public school in Cupertino California with a special technology focus. The participants included three classes of second grade and third grade students, each of 20 pupils. The three classes were all part of the same *village*, meaning each class has its own teacher, but they mostly follow the same curriculum because the teachers collaborate in planning. At the time this lesson was conducted, the village was engaged in a social studies curriculum to learn about communities. The goal of this technology lesson was to help students understand the abstract relation between maps and the communities they represent.

Unit Plan

This section provides detailed instructions for running a GPS mapping project with a group of elementary age students. It is recommended that the unit be conducted over three or four daily sessions of 60 to 90 minutes to allow students time to digest and synthesize each aspect of the experience.

Step 1: Students are Introduced to GPS. A GPS device is passed around the room for students to examine. The students are then engaged in a whole-class discussion and asked a series of probing questions: *What is the device called? What does it do? How does it work? What might you use it for?* This dialog should reveal the current level of understanding held by students in the class. In the tech-savvy community of Cupertino, California, most students knew the devices were called GPS, knew they provide location information, and knew they somehow used satellites. Still the teachers had to fill knowledge-gaps and correct misconceptions. For example, teachers helped the students understand that GPS devices do not work indoors because they require a "line-of-sight" to overhead satellites. The teachers also challenged the students think about the accuracy of the devices. Through trial and error, the students came to grasp that GPS data can vary by 5 to 10 feet at any given location.[1] The students were asked to consider this fact when planning their mapping effort.

Step 2: Project is Explained to Students. Students are told they will engage in a multi-session project to make a map of their school campus. They will do this by using a GPS device to record location data at various points around the school. The class will be spit into small groups of four or five students, each assigned a specific portion of the campus. The groups will take turns walking around the campus with the GPS devices, recording data for their assigned region. Finally, each of the groups will plot their data on a single large piece of graph paper until a full map of the school is produced.

Step 3: Students Get a Bird's Eye View. The students are told they must plan their data collection effort prior to walking around the campus with the GPS units. The students are then asked if it would be useful to view their campus as it might be seen from an airplane flying overhead. When this lesson was conducted at Portal, the students agreed that an overhead view would be a great help. With that as their motivation, the students were directed to websites that provide high-resolution aerial photography covering most of the United States: www.mapquest.com or www.imageatlas.globexplorer.com Using such websites, students (with aid of teachers) found an overhead image of their campus. A sample image is shown below:

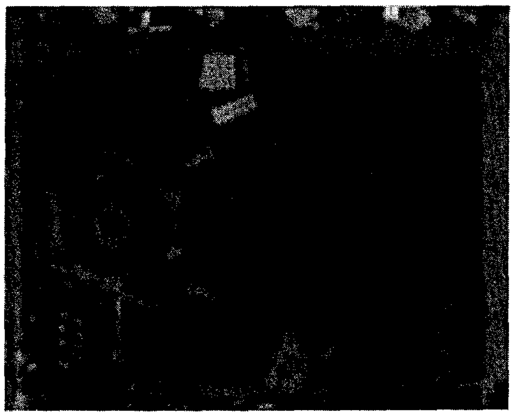

Figure 1: Aerial Photo of Portal Elementary School

[1] Technical Note on GPS Hardware: Most GPS receivers offer options for how the values of latitude and longitude are displayed. The standard format is to give values in degrees, minutes, and seconds. While this is a very common format, it may be confusing for young students. Fortunately most GPS receivers can be easily configured to display the data in degrees only, using decimal places instead of minutes and seconds. For example, latitude of 37 degrees, 19 minutes, 40 seconds can be alternatively displayed as 37.3278 degrees.

Step 4: Planning as a Class. The aerial photo is projected on a wall of the classroom for the whole class to view together. The teacher then challenges the class to split the campus into a number of smaller parts, each to be assigned to a specific group of students. A class discussion follows, moderated by the teacher. When this effort was done at Portal, the students decided to split the campus into four logical regions: *The Small Round Building*, *The Long V-Shaped Building*, *The Blacktop*, and *The Grass Field*. The class was then split into four groups by the teacher, each assigned to one of the regions listed above.

Step 5: Each Group Plans their Efforts. Once the groups have been formed and assigned to different regions of the campus, the next step is to have each groups plan their individual efforts. The teacher hands out a printed copy of the aerial photo to each of the groups and instructs them to plan the points they need to collect to map their region of the campus. They are to draw the points on the aerial photo and assign each point a letter (A,B,C...). To limit the data collection process, each group at Portal Elementary was instructed not to select more than 10 points. As an example of this effort, one of the groups at Portal chose to collect six points that they felt would describe the long v-shaped building they were responsible for. These points, labeled A through F, are shown in Figure 2 below:

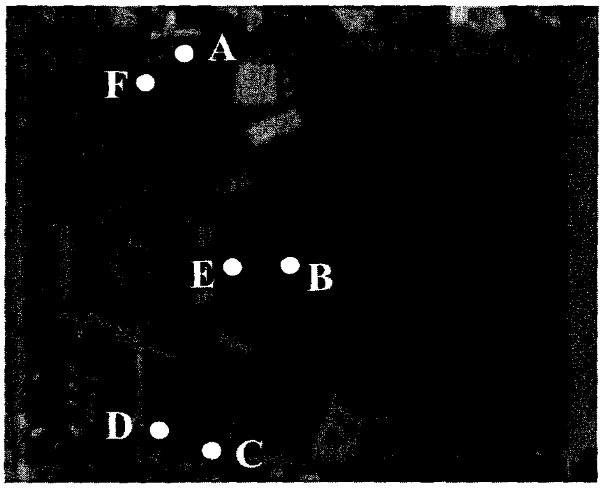

Figure 2: Waypoints identified by one of the student groups.

Step 6: Collecting Data. With their points planned on their printed aerial photos, each group is ready to go outside and collect their set of data. With adult supervision, they leave the room and walk around the campus, finding the real physical locations that correspond with the points they've drawn on their aerial photo. Using the GPS and a pad of paper, they note the latitude and longitude of each point they visit. A sample table of data collected by each group of students looks as follows:

Map Location	Latitude	Longitude
A	37.49544	121.86760
B	37.49520	121.86690
C	37.49533	121.86500
D	37.49520	121.86580
E	37.49430	121.86820

Table 1: Sample Table of GPS Data

As is evident in the data above, only the last few digits of each latitude and longitude are significant. The kids should "discover" this as they collect the data and ponder what it means. As a reference for teachers, the difference between 37.49555 and 37.49556 is approximately three feet in the physical world. Also, you should keep in mind that the GPS is only accurate to about five to ten feet. These facts offer valuable opportunities for class discussions about rounding, precision, and measurement. When the lesson was conducted at Portal, most students noticed that only the last few decimal places changed as they walked around the campus. Many students realized this was because the campus was not big enough to cause more substantial changes in latitude or longitude.

Figure 3 below shows a group of students working together to collect their location data. It was interesting to observe the children using the aerial photo of the campus to orient themselves with respect to their physical surroundings, looking for landmarks such as trees and buildings and recognizing for themselves that these landmarks looked very different when viewed from the ground as compared to the overhead perspective. In this way the abstract relationship between the aerial photo, the GPS data, and the real physical world became concrete.

Figure 3: Students work as a group to collect GPS data. The image on the left shows the group studying the aerial photo to determine where in the physical world they must go to collect their next data point. The image on the right shows two girls working together to collect the data for a single waypoint, one student works the GPS device while the other copies Longitude and Latitude values onto a written table.

Step 7: Preparing the Graph. At the end of Step 6, each group will have a table of values representing their section of the campus. The final effort is to plot these on a single large piece of graph paper. It is important to scale the data for the students so that the results fit nicely on the paper chosen. When the effort was conducted at Portal, the author scaled the data by first collecting four points with the GPS (the four corners of the school campus). By knowing the limits of the graph, it was possible to scale the data for the students so that the numbers were easy to plot on the chosen graph paper. If this project was to be conducted with older students, the scaling effort could be left up to the class as an additional learning opportunity.

Step 8: Graphing as Groups. The students take turns plotting their data on a single large piece of graph paper. Once the points are plotted, the students use a yardstick to connect the relevant points and outline the key features of the campus. Students can optionally color areas with crayons to represent grass, trees, blacktop, buildings, dirt, etc. On the following page, Figure 4 shows one of the student groups at Portal

Elementary drawing their portion of the map – the octagonal building that houses the administrative offices for their school:

Figure 4: Students plot their GPS data as a group. One student reads the data off the table while another draws the point on the graph. Students take turns in each role.

Step 9: Assessment: At the end of the unit, success can be evaluated by observing each group's ability to graph their portion of the school. Teachers can also assess how well students worked as a team and followed procedures for data collection. Each group may optionally be asked to explain their mapping strategy to the rest of the class. They could talk about what was the hardest part of the campus to graph and why. They may also discuss the number of points collected, the precision of the data, as well as sources of error in the collection process. When this lesson was conducted at Portal, students had a lively discussion about how they might make their graph more accurate. The students discovered for themselves that by collecting more points they could add detail to the structures drawn. Students also brainstormed on how GPS technologies might help professionals in various occupations perform their real-world jobs.

Concluding Remarks

The project was successfully completed by all three classes that took part in the effort, yielding impressive campus maps that the students displayed with pride. During a wrap-up group discussion, the students expressed that the project was fun and reported that it helped them understand more about maps, map-making, and the relationship between maps and the real world. During post-project discussions, all three teachers involved in the project expressed great satisfaction over the effort, indicating that the unit exceeded their curriculum goals while maintaining a high level of engagement with their students. All three teachers indicated a desire to repeat the project with future groups of students.

Acknowledgements

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