Title: A GPS scavenger hunt: Using performance-based instruction to meet National Science Education Standards

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A GPS scavenger hunt: Using performance-based instruction to meet National Science Education Standards

David S. Brown, Chris Freeman, Alex Wiseman

Abstract

The National Science Education Standards were designed to create scientifically literate citizens in the U.S. The standards not only show what students should know at each grade level, but also what they should understand and be able to do. The standards emphasize active learning where students engage in the process of science and not just hear about, read about, or watch others “do” science, but where each student does science. One method of engaging students in science learning is to have students participate in and/or work on science projects. This paper is divided into three parts. The first describes a project designed for 8th and 9th grade students based on the understanding and use of GPS hand-held units. Twenty students, all entering eighth and ninth grade, participated in a GPS/GIS activity during a summer technology academy. In small groups, students participated in a scavenger hunt that required them to use the GPS units. Students collected and recorded data, took digital pictures, entered the data and pictures into their power point presentations, and then presented their findings to the class. Geographic Information System (GIS) mapping software were used along side of topographic maps to identify and represent locations during the activity. The second part of this paper describes the results from a pre- and post-test administered to students to determine understanding of content requirements as well as confidence in areas of understanding. The results of the study showed an increase in content understanding and an encouraging level of excitement toward doing science. Results imply a relationship
between projects and performance that should also occur on a national as well as an international level. The final section of this paper describes results from 1999 TIMSS data showed the a similar correlation in which teachers in the United States, as well as teachers from 38 other countries, show a positive relationship between projects and performance. The assigned project meets national science standards and can be used by any teacher to allow students to “do” science while increasing performance.
A GPS scavenger hunt: Using performance-based instruction to meet National Science Education Standards

Introduction

Project-based learning describes a process where the students direct their own learning experiences and the teachers are facilitators who provide support for students and groups of students. In many cases, a theme has been provided by the teachers that allow creativity by students within the boundaries set up by the theme. Students are encouraged to create in-depth excursions into the topic the students are interested in. This constructivist approach to teaching is directly related to the National Science Standards.

Gatrell and Oshiro (2001) show the relationship between project-based learning and geography education. They demonstrate ways in which Geographic Information Systems (GIS), a project-based learning application, can be utilized in classrooms instead of the traditional teaching approach. Their study stresses the significance of using project-based learning and the increased amount of achievement resulting from this method of instruction. Increased achievement and using teaching approaches other than a traditional lecture approach are components of the National Standards.

The National Science Education Standards were designed to create scientifically literate citizens in the United States. The goals of the standards not only show what students should know at each grade level, and want they should understand and be able to do, but also suggest ways teachers can accomplish these tasks. The standards emphasize active learning where students engage in the process of science and not just hear about,
read about, or watch others “do” science, but where each student does science. One method of engaging students in science learning is to have students participate in and/or work on science projects. The goals of using project-based instruction are to increase positive attitudes concerning science while increasing science achievement and allowing students to participate in science. This is much different than simply hearing about science.

Rationale

It has been hypothesized that student who learn by inquiry-based teaching strategies will show a greater understanding of content and concept acquisition that students learning through expository learning. Examples of this concept have been documented in studies by Odom (1996), Rutherford (1998) and Brown (1997). Each research project set out to compare science scores from students involved in expository versus innovative teaching practices. Their research results describe increase science comprehension and achievement and more positive attitudes towards science.

Project-based learning has shown similar results. Diffily (2001) describes teacher as well as student benefits of project-based learning. She recognizes the fact that students in these types of classes can develop assigned themes in a more meaningful way than if the concepts were simply lectured by teachers. Teachers also benefit by allowing them the time to observe student learning through other means than simply tests or quizzes and providing ample opportunities to provide immediate feedback. Banks (1997) discusses similar opportunities for teachers in the realm of assessment. She discusses the
development of higher level thinking among students and the ease at which this can be obtained when project-based classrooms are properly organized.

Hypotheses

1) Science content knowledge would be increased as a result of the project-based academy;

2) The TEC academy would provide an increase of positive attitudes towards science and technology, attitudes representative of students wanting to use the technology in the future;

3) Students and teacher would understand that the project undertaken were directly related to real-world problems; and

4) Results from the academy would be similar to international findings.

National Science Education Standards

It is a universally accepted principle that all individuals need to be scientifically literate. In the U. S., this principle is described in the standards set for all students and teachers alike. The teachers must have the freedom and knowledge to educate their students in a way that will encourage learning and cooperative involvement in the schools. The students must be active learners, and the teachers must be a part of an educational system that promotes this. The National Science Education Standards describe an educational system in which all students demonstrate high levels of performance, in which teachers are empowered to make the decisions essential for effective learning, in which interlocking communities of teachers and students are
focused on learning science, and in which supportive educational programs and systems nurture achievement (National ). This system advocates classrooms such as a project-based learning environment and outcomes for students are examined in the goals for school science.

Goals for School Science – From the Standards

The goals for school science are to educate students in a way that they should be able to:

1) use appropriate scientific processes and principles in making personal decisions;

2) engage intelligently in public discourse and debate about matters of scientific and technological concern;

3) increase their economic productivity through the use of the knowledge, understanding, and skills of the scientifically literate person in their careers (National Education Standards); and

4) experience the richness and excitement of knowing about and understanding the natural world (National Research Council, 1996).

Schools are encouraged to implement the Standards and accept the goals. These schools will have their students actively learning science by engaging in inquiries that are interesting, are real world, and many times are project-based. When schools and teachers empower the students to create while learning, the increase of science
knowledge will result. Project-based learning shows every component of the goals of science.

The TEC Academy

With national attention focused on creating more effective methods of instruction while requiring science and other secondary teachers to develop active learners, the question seems not to be whether or not project-based learning should be used, but how much it should be used in the classroom. Teachers, however, do not always have the time to create these project-based activities for their classes and seem to always appreciate the help when available. The 2002, Technology, Education and Collaborative (TEC), held in the summer, was designed to introduce students and teachers to Geographic Information Systems (GIS) as well as its dependence on Global Positioning Systems (GPS). Three of the questions asked of this three-week summer technology academy were: 1) Can student knowledge significantly increase after attending a short course designed on a project-based curriculum? 2) Did the students feel the academy allowed the students to work with real life problems? And 3), was the work at the academy interesting and exciting enough to provide a motivation for them to pursue working with this form of technology in the future?

The Technology

Although a wide range of technology was used during the academy, emphasis was placed on using GPS receivers to help create GIS maps. The most important goal of the academy was to develop the ability and desire in students and teacher to actively
participate in activities and projects that use GIS mapping. The academy was designed around providing enough instruction so the participants could create their own projects in small groups. A brief explanation of GIS and GPS follows.

Global Positioning System

The term GPS stands for the Global Positioning System (FM 21-26, 1987). It is the only system today able to show an exact position on the Earth anytime, in any weather, anywhere on our planet. The GPS is funded by and controlled by the U. S. Department of Defense, even though studies show there are many hundreds of thousands of civil users of GPS worldwide. There are 24 GPS satellites that orbit at approximately 11,000 nautical miles above the Earth’s surface. These satellites transmit signals that can be detected by anyone with a GPS receiver. Using the receiver, a person can determine a location with great precision. One of the expected outcomes of this academy was to instruct the students on the use of hand-held GPS receivers. However, due to the skyrocketing uses for GPS technology, especially in the areas of outdoor recreation and vehicle navigation, most of the students already were well acquainted with GPS, making time needed for this instruction very minimal. More time was available for GIS instruction, which was also found to be not as needed as thought, not because of prior use by participants, but by the ease at which the material could be taught and learned.

Geographic Information System

A Geographic Information System (GIS) is defined as a digital database in which a common spatial coordinate system (latitude and longitude from the GPS) is the primary
means of reference. Individuals can begin using a GIS by inputting data from maps, aerial photos, satellites, surveys, as well as any available data table. This data can be stored, retrieved and queried in an effort to analyze, model and describe spatial statistics regarding the data. Creating a GIS map or series of maps is an important outcome of using a GIS.

An example of data that can be used in GIS mapping is that collected by the census bureau. The sample table and map in this paper show an excerpt from the 1990 U. S. Census Report. The data is downloaded into a GIS mapping program and used to create a map. One goal of this academy was to instruct all teachers and students on many of the uses of GIS mapping. As previously described, use of GIS was quite unlike the concept of GPS, none of the students or teachers had ever used GIS mapping, even though this technology has been available for almost 20 years. Surveys given at GIS presentations show that few individuals in education are aware of its existence or possibilities.

Below is a sample GIS data table. The information for this table came from the U.S. Census Bureau. The table is in a spreadsheet format. Student can either collect their own data or download preexisting data from the Internet or a web site. All students were required to obtain data using both methods during the academy.
Figure 1. Table created by the GIS mapping software showing U. S. Census data.

Once the data is obtained and placed in a spreadsheet format, the GIS mapping software allows individuals to manipulate the data in many way. One presentation of the data the students used on a daily basis is the creation of maps. All maps can be color-coded and there are “zoom” buttons allowing users to take a world map, zoom down to the country level, then the city level, and show city tract maps with neighborhood topography. The following map was created from the previous data.
Procedures

The 2002, Technology Education and Collaborative (TEC) summer academy was conducted at the University of Tulsa and hosted four high school teachers and 20 eighth and ninth grade students. The Oklahoma State Regents of Higher Education provided the funding to run the program. The academy lasted a total of three weeks during the first summer. All participants were required to apply for one of the limited spots, teachers and students alike, and a selection committee chose the most qualified and interested individuals. Once the group was selected, the four teachers attended the first week of the program, a week designed to instruct the teachers how to use the technology while
allowing them to plan the two weeks in which the students would be in attendance. The following two-weeks of the academy included attendance of the teachers as well as the 20 students. During these weeks, the teachers acted as facilitators while the students learned the technology and participated in and created projects and activities based on GPS and GIS.

Students were quick to learn the mapping software and with their prior knowledge of GPS found time to experiment with a greater variety of data and maps than originally prepared for. Three major group projects were completed by all students. These included a Tulsa Zoo project, a Scavenger Hunt, and the project designed entirely by the students, the Mapping Project.

The Scavenger Hunt

The scavenger hunt was the only project in the academy designed by the teachers; the other projects were student-created. The purpose of the hunt was threefold: collaboration, students learning to use technology, and students understand that the technology they are using is real world and by presenting results to others, they are participating in active teaching and learning. The process to achieve all three goals was initiated in the design of the activity. Initially, students were placed in groups of three, one to collect GPS data, one to collect digital pictures, and one to manually record data. There were approximately 16 sites and students were required to switch jobs after every five sites were discovered. This design encouraged collaboration. This also required each student to team all aspects of the technology as well as teach their part to their classmate. After all sites were visited, students returned to the computer lab, downloaded pictures,
created tables, and developed their own Power Point presentation to be given to the entire class. Each group completed similar but separate parts to the scavenger hunt and the presentations brought closure to the project.

Measures

The students and teachers were given several questionnaires throughout the study. Pre- and post-tests were administered to show the change in the amount of knowledge each participant possessed at the end of the academy concerning the use of certain technologies as well as content knowledge change. A post survey was also administered which asked questions on participants' attitude, questions asking for ideas on improving the academy, and questions on the relevance and possible uses of the GIS and GPS. Results were also compared to national and international data on related topics using TIMSS-R data.

TIMSS-R Data

The TIMSS-R data used represents the Third International Mathematics and Science Study - Repeat, conducted in 1995 (TIMSS) then again in 1999 (TIMSS-R; IEA, 2001). The study tested several hundred thousand students in 38 countries in science and math understanding. Along with the tests, all subjects were administered a survey asking questions on methods of instruction used by teachers, demographics of students, and information on school climate, study habits, and many other variables that might be related to achievement. This paper looks at national and international relationships between science scores and projects and attitudes.
Results

Results from this study are shown in the following tables. Table 1 shows the descriptive and inferential statistics for the pre and post test scores on content knowledge. Table 1 shows a significant increase in content knowledge on the questions asked on “map reading” and “understanding of census data”.

Table 1. Levene's test results of equality of variance and t-test results for equality of means for change in content knowledge by students.

<table>
<thead>
<tr>
<th>Levene's test for equality of variance</th>
<th>t-test for equality of means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
</tr>
<tr>
<td>reading maps</td>
<td>2.350</td>
</tr>
<tr>
<td>understanding census data</td>
<td>.281</td>
</tr>
</tbody>
</table>

<.05

The results from the questionnaire which asked teachers and students whether or not they would try to sue GIS mapping in the future is described in Table 2. The question asked if participants would try the technology in the future and answers were provided in a Likert-type scale with “1” representing never and “5” representing a “definite yes”. A mean of 4.06 for students and a mean of 4.83 for teachers were observed.

Table 2. Descriptive and inferential statistics on the question of the students' and teachers' desire to pursue the use of all technology further.

<table>
<thead>
<tr>
<th>Posttest participant type</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student</td>
<td>18</td>
<td>4.06</td>
<td>.873</td>
<td>.206</td>
</tr>
<tr>
<td>Teacher</td>
<td>6</td>
<td>4.83</td>
<td>.408</td>
<td>.167</td>
</tr>
</tbody>
</table>

Levene's test for equality of variance t-test for equality of means

<table>
<thead>
<tr>
<th></th>
<th>F</th>
<th>Sig.</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motivation to pursue further</td>
<td>5.735</td>
<td>.026</td>
<td>-2.085</td>
<td>22</td>
<td>.049</td>
</tr>
</tbody>
</table>
Table 3 shows the results from two questions that asked participants whether or not they saw the data and activities as being related to real life and if they saw real world context connections. A “1” represented a negative response to the question and a positive response was seen with a “5”. Teachers responded with a mean of 4.39 and students with an average response of 4.83 in regards to real life activities. In regards to students and teachers connecting the academy with real world contexts, means were 4.39 and 4.83 respectively.

Table 3. Descriptive and inferential statistics for questions on relating the activities in the academy to real world problems.

<table>
<thead>
<tr>
<th>Activities were related to real life</th>
<th>Posttest participant type</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students</td>
<td>18</td>
<td>4.39</td>
<td>1.092</td>
<td></td>
</tr>
<tr>
<td>Teachers</td>
<td>24</td>
<td>4.50</td>
<td>.722</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Connections to real world contexts</th>
<th>Posttest participant type</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Er. Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student</td>
<td>18</td>
<td>4.39</td>
<td>.778</td>
<td>.183</td>
<td></td>
</tr>
<tr>
<td>Teacher</td>
<td>6</td>
<td>4.83</td>
<td>.408</td>
<td>.167</td>
<td></td>
</tr>
</tbody>
</table>

Significance testing for real world contexts

<table>
<thead>
<tr>
<th>Levene's test for equality of variance</th>
<th>t-test for equality of means</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>Sig.</td>
</tr>
<tr>
<td>world contexts</td>
<td>6.785</td>
</tr>
</tbody>
</table>

<.05

Results from the data analysis of the 1999 TIMSS-R show a significant relationship between attitude and science understanding as well as between science
comprehension and working with projects (Table 4). This is seen in the United States as well as in international comparisons.

Table 4. Significant results of United States and international data collected on attitude with project-based activities and science achievement in schools.

<table>
<thead>
<tr>
<th>Positive Attitudes</th>
<th>Science scores</th>
<th>Work on Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson r</td>
<td>.192**</td>
<td>.179**</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>N</td>
<td>8461</td>
<td>174,000</td>
</tr>
</tbody>
</table>

Discussion

The results from the study show that students and teachers alike see the real world application for the technology and activities done during the technology academy. The academy was designed with this goal in mind and this goal was accomplished. Students and teachers also showed in their survey answers that they were willing in the future to pursue GIS and GPS use. This was also a goal of the academy and was accomplished as well. The final results showed the increase of content knowledge from the curriculum of the academy. Student achievement and understanding of content is many times the most important outcome of any innovative method of instruction. For this academy, attitude and technology use was just as important, but an increase in knowledge is a benefit.

Results from the TIMSS-R data showed the responses from the academy survey to be similar to what is occurring throughout the United States. Attitudes are much related to achievement and student involved in projects at school tend to have higher
science scores than those not doing as many projects. Project-based learning, therefore, appears to be a valuable method of instruction.

Conclusions

The National Education Science Standards emphasize active learning, such as project-based learning. Project-based learning occurs where students engage in the process of science, working on projects in groups and presenting results to classmates. National and international data support the results of the 3-week technology academy in which students and teachers alike were brought to the University of Tulsa's campus to learn to use GIS and GPS, as well as other forms of technology. The results show that the student generally understand when real world data is being used, they see ways to use technology in their future academic careers, and content knowledge can be increased from using projects for learning. With the high correlation between attitude and science achievement, it is imperative that science educators find ways to make learning science
Bibliography


