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

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Abstract

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 what 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. 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. In summary, 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, 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.

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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 goals of the National Science Education Standards (National Research Council, 1996).

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 one 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 what 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 and increase achievement in science while allowing students to participating 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 an inquiry approach have been documented in studies by Odom (1996), Rutherford (1998) and Brown (1997). Each research study 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) 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 Research Council, 1996). 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, 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. These schools will have 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, learning 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

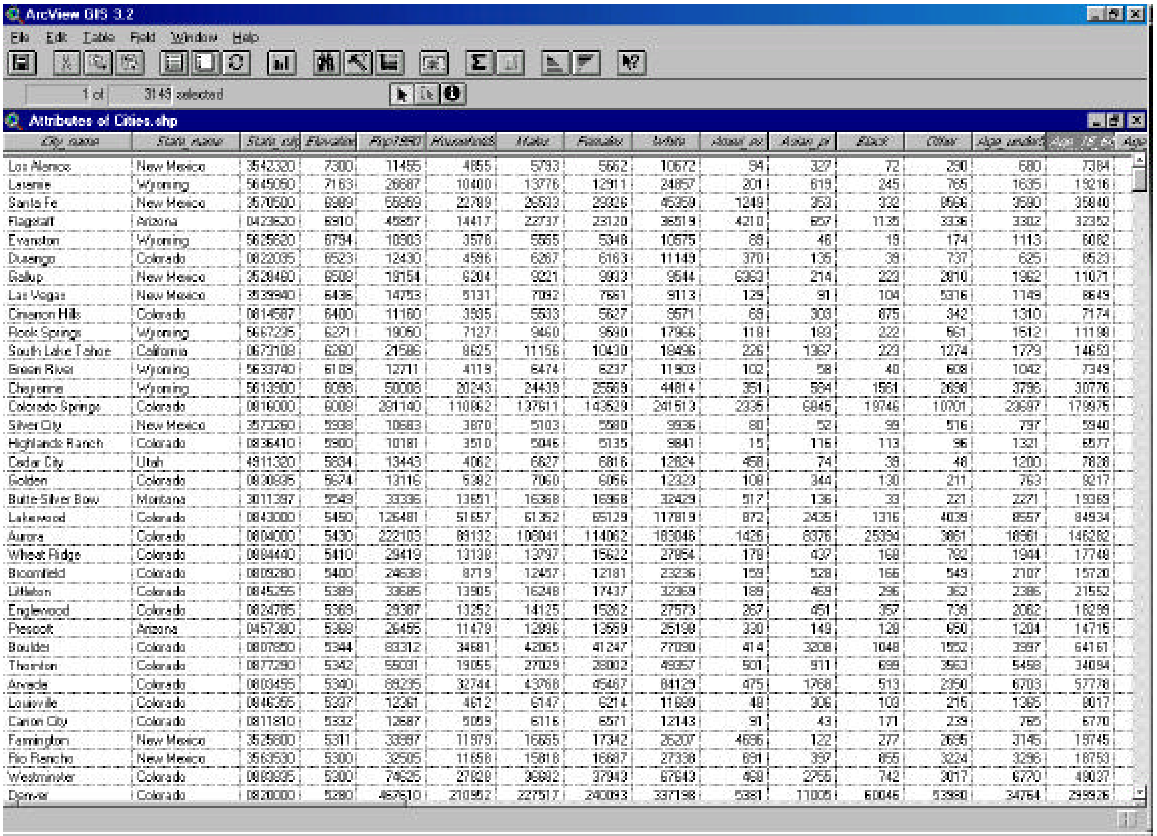
The term GPS stands for the Global Positioning System. It is the only system today able to show an exact position on the Earth anytime, in any weather, anywhere on our planet. The GPS is funded by and controlled by the U. S. Department of Defense, even though studies show there are many hundreds of thousands 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 (IEA, 2001). 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.



ArcView GIS 3.2

File Edit Table Field Window Help

1 of 3149 selected

Attributes of Cities.shp

City_name	State_name	State_cit	Elevation	Pop1990	Households	Male	Female	White	Amer_es	Asian_pi	Black	Other	Age_under	Age_18_64
Los Alamos	New Mexico	3542320	7300	11455	4855	5793	5662	10672	94	327	72	290	680	7384
Laramie	Wyoming	5645050	7163	26687	10400	13776	12911	24857	201	619	245	765	1635	19216
Santa Fe	New Mexico	3570500	6989	55859	22789	26533	29326	45359	1249	353	332	8596	3590	35840
Flagstaff	Arizona	0423620	6910	45857	14417	22737	23120	36519	4210	657	1135	3336	3302	32352
Evanston	Wyoming	5625620	6794	10903	3578	5555	5348	10575	89	46	19	174	1113	6082
Durango	Colorado	0822035	6523	12430	4596	6267	6163	11149	370	135	39	737	625	8523
Gallup	New Mexico	3528460	6508	19154	6204	9221	9933	9544	6363	214	223	2810	1962	11071
Las Vegas	New Mexico	3539940	6436	14753	5131	7092	7661	9113	129	91	104	5316	1149	8649
Cimarron Hills	Colorado	0814587	6400	11160	3935	5533	5627	9571	69	303	875	342	1310	7174
Rock Springs	Wyoming	5667235	6271	19050	7127	9460	9590	17966	118	183	222	561	1512	11198
South Lake Tahoe	California	0673108	6260	21586	8625	11156	10430	18496	226	1367	223	1274	1779	14653
Green River	Wyoming	5633740	6109	12711	4119	6474	6237	11903	102	58	40	608	1042	7349
Cheyenne	Wyoming	5613900	6098	50008	20243	24439	25569	44814	351	584	1561	2698	3796	30776
Colorado Springs	Colorado	0816000	6009	281140	110862	137611	143529	241513	2335	6845	19746	10701	23697	179975
Silver City	New Mexico	3573260	5938	10683	3870	5103	5580	9936	80	52	99	516	797	5940
Highlands Ranch	Colorado	0836410	5900	10181	3510	5046	5135	9841	15	116	113	96	1321	6577
Cedar City	Utah	4911320	5834	13443	4062	6627	6816	12824	458	74	39	48	1200	7828
Golden	Colorado	0830835	5674	13116	5382	7060	6056	12323	108	344	130	211	763	9217
Butte-Silver Bow	Montana	3011397	5549	33336	13651	16368	16968	32429	517	136	33	221	2271	19369
Lakewood	Colorado	0843000	5450	126481	51657	61352	65129	117819	872	2435	1316	4039	8557	84934
Aurora	Colorado	0804000	5430	222103	89132	108041	114062	183046	1426	8376	25394	3861	18961	146282
Wheat Ridge	Colorado	0884440	5410	29419	13138	13797	15622	27854	178	437	168	792	1944	17748
Broomfield	Colorado	0809280	5400	24638	8719	12457	12181	23236	159	528	166	549	2107	15720
Littleton	Colorado	0845255	5389	33685	13905	16248	17437	32369	189	469	296	362	2386	21552
Englewood	Colorado	0824785	5369	29387	13252	14125	15262	27573	267	451	357	739	2062	18299
Prescott	Arizona	0457380	5368	26455	11479	12896	13559	25198	330	149	128	650	1204	14715
Boulder	Colorado	0807850	5344	83312	34681	42065	41247	77090	414	3208	1048	1552	3997	64161
Thornton	Colorado	0877290	5342	55031	19055	27029	28002	49357	501	911	699	3563	5458	34094
Arvada	Colorado	0803455	5340	89235	32744	43768	45467	84129	475	1768	513	2350	6703	57778
Louisville	Colorado	0846355	5337	12361	4612	6147	6214	11899	48	306	103	215	1365	8017
Canon City	Colorado	0811810	5332	12687	5059	6116	6571	12143	91	43	171	239	765	6770
Farmington	New Mexico	3525800	5311	33997	11979	16655	17342	26207	4696	122	277	2695	3145	19745
Rio Rancho	New Mexico	3563530	5300	32505	11658	15818	16687	27338	691	397	855	3224	3296	18753
Westminster	Colorado	0883835	5300	74625	27828	36682	37943	67643	468	2755	742	3017	6770	49037
Denver	Colorado	0820000	5280	467610	210952	227517	240093	337198	5381	11005	60046	53980	34764	299926

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.

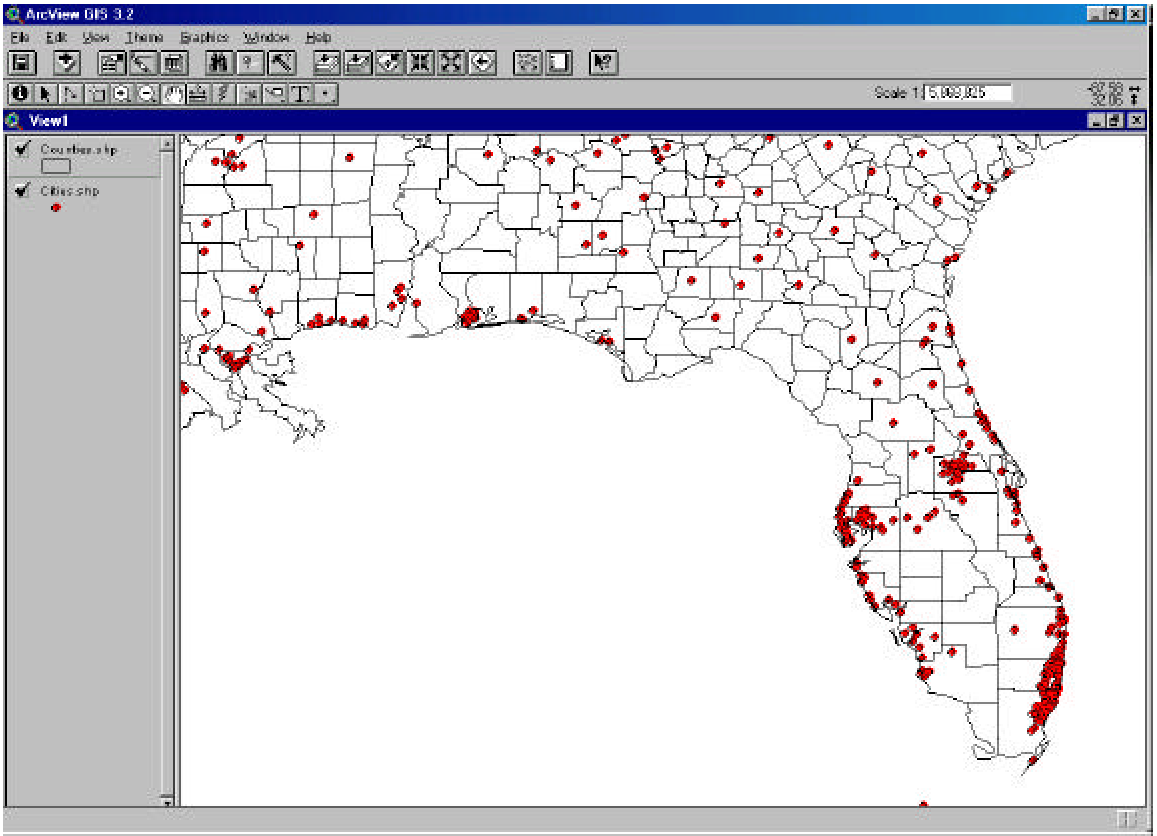


Figure 2. Map created by the GIS mapping software showing all counties and major cities in the Southeastern United States.

Academy Activities and 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.

Student 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 competed 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 three-fold: 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 learn 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 data.

TIMSS Data

TIMSS stands for the Third International Mathematics and Science Study, conducted in 1995 then again in 1999 (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 show 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.

	Levene’s test for equality of variance		t-test for equality of means		
	F	Sig.	t	df	Sig. (2-tailed)
reading maps	2.350	.134	-3.049	35	.004*
understanding census data	.281	.599	-4.186	35	.000*

<.05

The results from the questionnaire which asked teachers and students whether or not they would try to use 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.

Posttest participant type	N	Mean	Std. Deviation	Std. Error Mean
Student	18	4.06	.873	.206
Teacher	6	4.83	.408	.167

Levene's test for equality of variance			t-test for equality of means		
	F	Sig.	t	df	Sig. (2-tailed)
Motivation to pursue further	5.735	.026	-2.085	22	.049

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.

Activities were related to real life

Posttest participant type	N	Mean	Std. Deviation
Students	18	4.39	1.092
Teachers	24	4.50	.722

Connections to real world contexts

Posttest participant type	N	Mean	Std. Deviation	Std. Er. Mn
Student	18	4.39	.778	.183
Teacher	6	4.83	.408	.167

Significance testing for real world contexts

	Levene's test for equality of variance		t-test for equality of means		
	F	Sig.	t	df	Sig. (2-tailed)
world contexts	6.785	.016	-1.327	22	.198
<.05					

Results from the data analysis of the 1999 TIMSS 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.

		Science scores		Work on Projects	
		US	International	US	Intern.
Positive Attitudes	Pearson r	.192**	.179**	.167**	.090*
	Sig. (2-tailed)	.000	.000	.000	.000
	N	8461	174,000	8461	174,000

Discussion

The results from the study show that student 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 data showed the responses from the academy survey to be similar to what is occurring throughout the United States. Attitudes are very 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 relevant and enjoyable.

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