GIS in High School Integrates Geography with Technology: A Case Study

Suzanne P. Wechsler
California State University Long Beach
Lisa A. Pitts
California State University Long Beach

This paper describes the design, implementation, and effectiveness of a high school-level course in Geographic Information Systems (GIS). The intent of the course was to instruct students in the use of GIS technology, and in doing so, teach geographic concepts and increase students' community awareness, computer capabilities, and technology competency. A survey administered both before and after the course offerings quantifies the positive influence of this GIS course on students' perceptions of geography, their GIS and computer competencies, and their relationship to their local community. The success of this course indicates that GIS can be used as a mechanism to integrate geography training with curriculum standards pertaining to technology. This case study demonstrated the value of a high school GIS elective and provides a model that high school faculty can build on to develop, promote, and integrate in a high school GIS elective.

Introduction

Geographic Information Systems (GIS) are a combination of hardware, software, and geospatial data that enable complex geospatial analyses. In a GIS, maps are stored as data layers. These layers and their associated spatial databases can be stored, visualized, and analyzed simultaneously, enabling users to ask and answer spatial questions. These versatile maps and databases have multiple applications in numerous fields that include, but are not limited to, resource management, marine science, agriculture, forestry, climate and other environmental areas, local government, public safety, risk management, site planning, transportation, and business. GIS technology can improve the quality of classroom learning by widening the scope of teaching and exposing students to the information-rich society in which they live (Mackaness 1994).

A 2002 study found that, at the high school level, geography-related lessons that used GIS were lacking. Those that did exist emphasized GIS in association with a particular content area (Kerski 2003). Some high schools implement GIS by using the technology as a mechanism to teach a particular subject matter. For example, courses in marine biology and earth science use laboratory assignments designed to utilize GIS technology, which enables students to answer specific questions and investigate data. Although the students do not learn specifically about GIS theory, they are exposed to GIS software and technology (Loveall and Bauer 2004).

A semester-long GIS elective may prove to be effective in enabling high school students to master both geographic concepts and computer skills. The present research demonstrated the development and implementation of a high school elective course dedicated to teaching GIS and investigated the effectiveness of this course as a mechanism for teaching geography concepts, community awareness. and computer skill development.

Background

The need for enhanced geography education is evident. Americans in the age range of eighteen to twenty-four came in second-to-last among nine countries in an international geography survey that tested geographic knowledge of more than 3,250 young adults from the United States, Canada, Mexico, France, Germany, Italy, Sweden, Great Britain, and Japan (*National Geographic* 2002). More than half (55%—an increase of 25% since the 1988 survey) of the U.S. respondents reported that they had a course in school that was devoted to geography. Students who had been exposed to a geography course performed better on the country identification portion of the quiz. However, the percentage of U.S. respondents, who indicated that it is important to know how to read a map and know where countries in the news are located, dropped by 31% and 10% respectively since the 1988 survey.

National and Local Educational Standards

The United States does not have a "national curriculum" like that of the United Kingdom or Russia. However, in the 1990s, the United States began to set and develop national content standards for nearly all academic subjects. These national standards are voluntary because education in the United States is principally the responsibility of the states and localities. A characteristic of the American education system is local control, where boards of education and teachers make decisions about curriculum, and national standards provide a set of criteria by which these decisions can be made (NSES 2004; Woodward 1999). States create their own content standards, using these national standards as a starting point. For example, in 1998 California adopted a series of content standards for K–12 education. These include content standards for mathematics, English, history-social science, and science (California Department of Education 2004). Standards specific to geographic knowledge are not addressed directly, but are subsumed under the standards for social sciences (human, social, and political geography) and physical sciences (physical geography).

National Geography Standards

In response to the apparent decline in geographic competencies in the United States, a national group of educators, parents, and members of business, professional, and civic organizations developed a consensus regarding the study of geography. This resulted in the 1994 "National Geography Standards," a set of eighteen core knowledge areas that constitute geographic literacy (NCGE 2004; *National Geographic* 2004). These standards are not required as part of the state standards; their adoption is at the discretion of individual instructors.

National Technology Standards

Technology standards for K–12 education were developed in a manner similar to the development of the National Geography Standards, by the International Society for Technology in Education (ISTE). The ISTE, a professional organization, collaborated with educators, education associations, government, business, and private foundations to develop a set of technology standards for students and teachers (ISTE 2004a; ISTE 2004b). The ISTE divides technology foundation standards into six categories. The standards are intended to be used by teachers as guidelines for planning technology-based activities (ISTE 2004a). The International Technology Education Association (ITEA) has developed twenty content standards for technological literacy, which is defined as the ability to use, manage, assess, and understand technology (ITEA 2004).

GIS in K–12 Education

As the push for standards-based education and academic testing and accountability has grown, courses that focus solely on geography have been removed from the curriculum. However, technology-related standards that focus on the integration of technology into the classroom are gaining favor in educational communities. A course in geographic information systems (GIS) would provide an opportunity to integrate geographic concepts with technology standards.

As of 2003, fewer than 2% of high schools in the United States had acquired GIS software. A survey of high school teachers who own GIS software found the following. Less than half of those secondary education teachers who own GIS are using it. GIS is predominantly used by science teachers, not geography teachers, and is perceived as difficult to use. Teachers who are using GIS use it to accomplish a single task. Teachers reported that they do not use GIS because they cannot find a way to employ it in teaching mandated standards (Kerski 2003; Kerski 2001).

Barriers to the success of GIS in the K–12 curriculum include inadequate access to appropriate hardware and limited time for curriculum preparation. Often the GIS software requirements do not match the schools' hardware capabilities. Faculty who wished to use GIS to teach geography or other subjects indicated the need to spend the time working through the software in order to be comfortable with it before implementing it in the classroom (Kerski 2003; Meyer et al. 1999).

Many educators expressed reluctance to institute GIS programs until they have a firm understanding of the fundamental principles behind GIS. Most teachers with GIS experience have received it through supplemental training opportunities (Kerski 2003). The need for these in-service teacher-training workshops has been addressed by programs such as GISAccess, an NSF-funded project at Cypress College (Cypress, CA), which created an institute that used active learning methods to demonstrate and teach the basic concepts of GIS to participants and provided "hands-on" practice with the software. High school and university instructors participated in a two-week institute to learn about the fundamentals of GIS and then developed a GIS-based project for use in their classrooms (Hobbs and Johnson 2000). Other workshops have aimed to train K–12 teachers to use GIS to teach specific subjects such as natural hazards (Guiterrez et al. 2002). GIS training is not part of pre-service teacher preparation, which impedes its adaptation in the classroom and curriculum.

Methods

A GIS technology-based course integrated with the social sciences curriculum would enable students to examine the relationships between places, cultures, and people, and expose relationships between themselves, their community, and the world. This paper presents a case study that demonstrates the development and effectiveness of a GIS course that was designed to use GIS technology to teach geographic concepts. The course was implemented in a twelfth-grade class at West Covina High School, West Covina, CA.

Administrative Support

In January 2002, an elective course in GIS was presented to and approved by high school history faculty, the high school principal, and the school board. School administrators were supportive of using GIS as a mechanism to integrate technology on campus. The school superintendent ensured that appropriate hardware and software were available for the course. The school purchased a site license to the ESRI ArcView desktop GIS software program through the ESRI K–12 Education program. The course was taught by an instructor who was not part of the high school faculty and had five years of professional GIS experience.

Demonstration Effort

In February 2002, a pilot course was offered, the goals of which were to demonstrate that GIS could be effectively implemented in a high school and would generate sufficient support for teaching a GIS course during the following year. Twenty students enrolled in this course. Following the success of the pilot program, the course was offered in fall 2002 (forty students) and spring 2003 (twenty students). The course was then offered in subsequent semesters. The students enrolled in the fall 2002 and spring 2003 courses participated in this evaluation effort.

Course Design

The GIS course first trained students in the use of computers. This was followed by a series of ten lessons (Table 1). The course developed for this demonstration drew upon a variety of resources; the source for each lesson is identified in Table 1. Each lesson was designed to be in compliance with each set of standards: National Geography Standards, National Technology Standards, and the California Social Science Standards. The authors can provide lists that describe the specific standards that are satisfied by each lesson.

Table 1: Lessons Used in the GIS Course and Associated Sources

Lesson and Source*	Brief Description
Introduction to computers	Students create a resume, attach it to an e-mail sent to the instructor.
1. Introduction to GIS: Paper GIS (Benefiel 1995)	Determine a location for a new school and a new house using raster and vector. Data sources include overlay transparencies and paper drawings of water, other schools, and roads.
2. Intro to GIS: Getting Started with ArcView (Malone, et al. 2002)	Students are introduced to ArcView GIS through a video and software demonstration.
3. Intro to GIS: What is Community? (Lander 1999)	Explore the city of West Covina on maps at various scales. Learn to add and display geographic and census data.
4. Geographic Basics: Projections (ESRI 2004)	Concepts of projections and scale are introduced by visualizing the effects of projection and associated distortion.
5. Physical Geography: Volcanoes and Earthquakes (Malone, et al. 2002)	Observe patterns of volcanoes and earthquakes, explore plate boundaries and landforms.
6. Observing El Niño, and other Climatic Effects (Malone, et al. 2002)	Georeference and compare images of land and sea surface temperatures to investigate climatic anomalies.
7. Digitizing (developed by instructor for this course)	Create land parcel boundaries (commercial, residential) for the city by on-screen digitizing. Perform spatial queries with other city features.
8. Getting the Data In: a Field Project (Lander 1999)	Develop data collection requirements, collect information about parked vehicles in the school lot, and map collected data.
9. Exploring Population (Malone, et al. 2002)	Observe changes in population distribution over the past 2,000 years and speculate why change has occurred.
10. Line in the Sand (Malone, et al. 2002)	Discuss and analyze cultural and physical features that influenced the boundary created by the Treaty of Jeddah and propose alternate borders.

*Lessons were adapted from these sources and modified to pertain to the City of West Covina.

The course culminated in a Community Atlas project. The Community Atlas program, sponsored by ESRI, encourages students to use GIS to develop Web sites that depict aspects of their community. Students first reviewed existing community atlas projects. Then they selected a topic concerning the local city and collected and developed a Web site using their newly acquired GIS skills (using FrontPage® Web-development software). The community atlas final project was well suited to the goals of the course in that it enabled students to combine computer technology and GIS skills with geography and spatial literacy to understand and communicate about an aspect of their community. Table 2 presents the GIS problems identified and the results of the data gathering by the students.

Evaluation of the Demonstration

The effectiveness of the GIS course was assessed using a survey that was administered to the students both before and after they had taken the GIS course (referred to as the pre-test and post-test). The purpose of the survey was to determine the impact the course had on:

- knowledge about and attitudes towards the field of *geography*;
- knowledge about and attitudes towards *GIS*;
- students' evaluations of their *computer* skills; and
- students' understanding of the use of GIS data in *community* projects.

Table 3 lists the survey items by category (*geography, GIS, computers, community*). The responses were based on a Likert scale, which ranged from 1 to 5 (1 = strongly disagree and 5 = strongly agree), with lower responses indicating disagreement with the statement.[1] Thirty-six students completed the pre-class survey and nineteen students completed the post-class survey (out of a combined class total of sixty). The survey was voluntary. Human subject restrictions made it impossible to match the pre- and post-tests. Therefore, comparison on a student-by-student basis could not be made.

[1]Survey questions numbers 4, 8, 19, 25, 26, and 27 were worded in such a way that a low response indicated agreement (rather than disagreement) with the statement. Results for these questions were transposed so that comparable analyses could be made among survey questions.

Table 2: Examples of Community Atlas Projects Undertaken by the GIS Classes

Project Title	Description
Trees of West Covina	The City of West Covina is responsible for the trimming and watering of city trees. A map was made using data from an arborist to show the spatial distribution of the trees.
Restaurants of West Covina	Using the online yellow pages, 156 restaurant addresses and type were recorded. Addresses were geocoded, resulting in 9 maps showing 11 different cuisines for 156 restaurants in the city.
Price Ranges and Distribution of Houses in West Covina	Using information from a local Real Estate seller, the locations of current homes for sale were geocoded. Home locations were displayed, with median household income obtained from the 2000 Census. The map identified a higher distribution of homes for sale in regions of higher median income.
Age Demographics of West Covina	The distribution of ages in the city was mapped using 2000 Census data.
Where Do Students Live?	All 2003 West Covina High School students' addresses (without names) were provided in spreadsheet format, geocoded and mapped.
Hair and Nail Salons of West Covina	The Internet was used to find addresses for all hair and nail salons in the city. Addresses and services were entered into a spreadsheet and mapped using geocoding.
Redevelopment Sites in West Covina	This map used the city's redevelopment Web site to obtain addresses and map redevelopment areas.
Ethnic Population in West Covina	This project mapped the ethnicities Caucasian, African American, Hispanic, Native American, and Asian, to demonstrate the distribution of the different ethnicities throughout the city.
Gas Stations in West Covina	The location and services offered by gas stations in the city was mapped. Data was created by geocoding their addresses and calling each station to find out which services they offer (smog checks, auto repairs, food mart, and operating hours).
Fast Food in West Covina	Five maps were created to identify the location and distribution of fast food outlets by zip code.
Crimes in West Covina	The goal of this research project was to identify the density and pattern of city crime and relate it to city features, i.e. proximity to malls and schools.

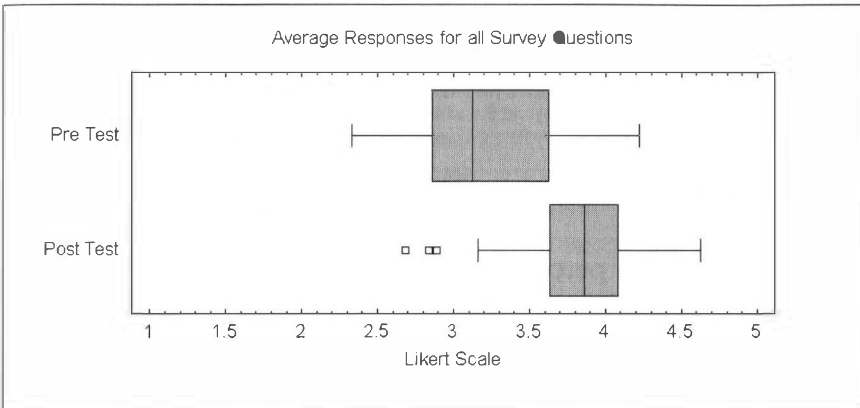
Table 3: Survey Questions by Category

#	Category	Question*
1	Geography	I have the skills to analyze and present findings based on geographic research.
2	Geography	I know where to find geographic data.
3	Geography	I feel geography affects my life daily.
4	Geography	Geography and GIS are the same thing.
5	Geography	I know what maps are used for.
6	Geography	I have the skills to plot geographic data on maps, charts, tables, and graphs.
7	Geography	I feel I have learned a lot of geography in school.
8	Geography	The only thing that one can do with a degree in geography is teach.
9	Geography	I like geography.
10	Geography	I understand the principles of geography.
11	Geography	I have the skills to collect geographic data from electronic sources.
12	GIS	I understand the many applications of GIS.
13	GIS	I can apply GIS to a career path.
14	GIS	I will use GIS technology in my future occupation.
15	GIS	I can apply GIS and geography to other areas of study.
16	GIS	People in the field of GIS spend time outdoors in the "field" collecting data.
17	GIS	GIS is used in science-related work.
18	GIS	I feel that GIS is an expanding career option.
19	GIS	GIS requires a lot of math and computer knowledge.
20	GIS	I know what ArcView is.
21	GIS	I know what ArcView is used for.
22	GIS	I know how GIS technology affects me every day.
23	GIS	I know the fields that GIS is used in.
24	GIS	I know what GIS is.
25	GIS	GIS requires math skills.
26	GIS	GIS requires science skills.
27	GIS	All people in the field of GIS sit at a computer all day long.
28	GIS	I know how GIS is used today.
29	GIS	GIS is useful in many career paths.
30	Computers	I feel comfortable with my computer skills.
31	Computers	I can work with tables.
32	Computers	I can create folders for storage and retrieval of my files.
33	Computers	I know how to use a computer.
34	Computers	I can use a database.
35	Community	I can show community data creatively and informatively.
36	Community	I know a lot about the community in which I live.
37	Community	I have skills that are useful to business in my community.
38	Community	I feel confident that I can find data about my community.
39	Community	I feel I can contribute to my community.
40	Community	I feel I contribute to my community.

Results and Discussion

Overall Results (Pre versus Post)

Students' t-tests (parametric) and Mann Whitney U-tests (non-parametric) were performed to examine differences between the overall pre-test and post-test means and medians for the forty survey questions. There was a significant difference between results from the pre-test and post-test for both the t-test ($t = -5.66$, $p = 0.00$, $a = 0.05$) and Mann Whitney U test ($W = 1316$, $p = 0.00$) (Statgraphics 1997). Figure 1 depicts a box plot of the survey data, which describes the pre-post changes in response to the survey.

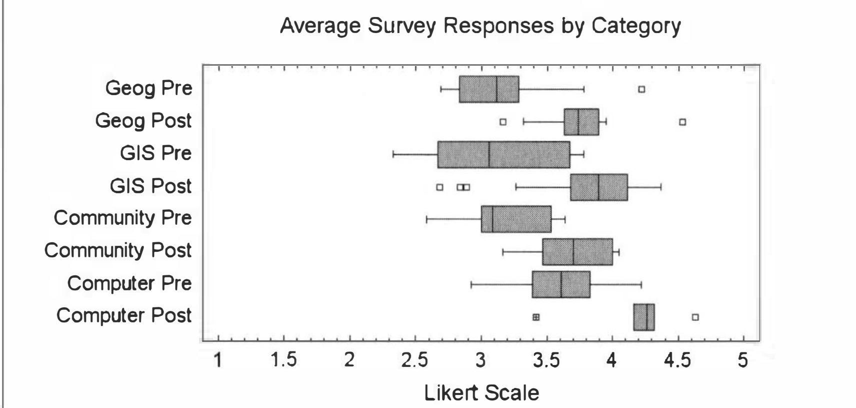


The boxes enclose the middle 50%, lines (whiskers) extend from each end of each box to the lower and upper quartiles. Values beyond the whiskers but within the three inter-quartile ranges are plotted as individual points.

Figure 1: Box plot of the distribution of the forty survey responses.

Survey questions were separated into categories based on the general area of knowledge that the question addressed. The Students' t-test and Mann-Whitney W test were performed to compare means and medians respectively of pre- and post-test responses for the questions within each category (Figure 2). Results indicate that there were significant differences between the pre- and post-test results for the overall dataset, and for the specific clusters of questions related to *geography, GIS, computers,* and the *community* (using a two-tailed analysis of significance at the 95% confidence level).

For each survey question, responses were grouped into categories of agreement (Likert responses of 4–5) or disagreement (Likert responses of 1–2). The percent of respondents who "agreed" and "disagreed" in both the pre- and post-tests was computed for each question.



The boxes enclose the middle 50%, lines (whiskers) extend from each end of each box to the lower and upper quartiles. Values beyond the whiskers but within the three inter-quartile ranges are plotted as individual points and outliers (values more than three quartile ranges) are identified with a "+".

Figure 2: Box plot of Survey Responses by Category.

The average of the percent of responses in the "agree" and "disagree" categories (Figure 3) provides a qualitative indication of the influence of the GIS course. After taking the GIS course, students, on average, tended to agree more and disagree less with the survey questions. This suggests that the course had a positive impact on perceptions. Responses for the pre- and post-tests were evaluated for each of the survey question categories: *geography, GIS, computers,* and *community*.

Category Results: Geography (Pre versus Post)

Table 4 provides results for survey questions that specifically addressed geography. Students' t-tests were conducted to examine differences between mean pre- and post-test responses. Differences were significant for seven of the eleven geography-related questions (based on a two-tailed test). The course significantly increased students' geographic knowledge. After taking the course, students perceived that geography affects them daily (question 3). They felt that they possess the skills to analyze and present findings based on geographic research (question 1), know where to find geographic data (question 2), have the skills to plot geographic data (question 6), understand the principles of geography (question 10), and have the skills to collect geographic data from electronic sources (question 11). Students also indicated that they know what maps are used for (question 5, significant for a two-tailed test).

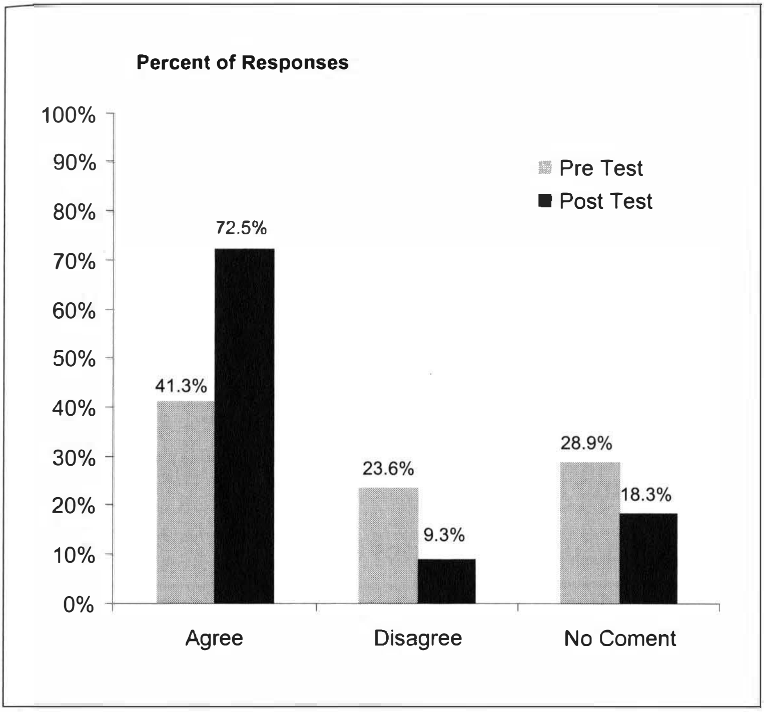


Figure 3: Average of percent of responses.

Table 4: Comparison of Means and Medians for Geography-Related Survey Questions

Question #	Pre Mean	Post Mean	Mann-Whitney W statistic	W-test p-value	t-test t-statistic	t-test p-value
1+*	2.81	3.84	552.5	0.00	-4.43	0.00
2+*	2.83	3.63	501.5	0.00	-3.19	0.00
3+*	3.25	3.74	440.5	0.07	-1.83	0.07
4	3.11	3.32	426.0	0.11	-0.88	0.38
5+*	4.22	4.53	436.0	0.05	-2.02	0.05
6+*	2.69	3.89	555.0	0.00	-4.57	0.00
7	3.11	3.16	347.5	0.93	-0.15	0.88
8	3.78	3.74	338.5	0.95	0.18	0.86
9	3.28	3.63	401.0	0.28	-1.26	0.21
10+*	3.28	3.95	476.5	0.01	-2.86	0.01
11+*	3.00	3.74	495.5	0.00	-2.93	0.00

* indicates that means between the pre- and post-tests are significantly different; + indicates that medians are significantly different at the 95% confidence level, based on a two-tailed test.

Category Results: GIS (Pre versus Post)

Table 5 presents results for survey questions that specifically addressed GIS. There are significant differences between the pre- and post-test mean and median responses for twelve of the eighteen GIS-related survey questions (based on a two-tailed test). The GIS course significantly developed students' GIS skills. After taking the course, students indicated that they understood many applications of GIS (question 12), could apply GIS and geography to other areas of study (question 15), and perceived GIS as an expanding career option that could be applied to and is useful in many career paths (questions 18, 13, and 29). Students reported that they know what GIS and ArcView GIS software is, know what GIS is used for (questions 24, 20, and 21), understand how GIS is used and by what fields, and understand how GIS technology potentially affects them (questions 28, 23, and 22).

Table 5: GIS-Related Survey Questions Results

Question #	Pre Mean	Post Mean	Mann-Whitney W statistic	W-test p-value	t-test t-statistic	t-test p-value
12+*	2.33	3.89	594.5	0.00	-5.68	0.00
13+*	3.56	4.00	431.0	0.07	-1.93	0.06
14	3.25	3.26	338.0	0.95	-0.06	0.96
15+*	3.50	3.94	416.5	0.03	-2.10	0.04
16	3.67	3.78	348.5	0.63	-0.43	0.67
17	3.69	3.82	340.0	0.42	-0.83	0.41
18+*	3.69	4.22	433.5	0.03	-2.38	0.02
19	2.50	2.68	372.0	0.56	-0.80	0.43
20+*	2.75	4.26	581.0	0.00	-5.17	0.00
21+*	2.67	3.95	556.5	0.00	-4.28	0.00
22+*	2.89	3.89	557.5	0.00	-4.77	0.00
23+*	3.00	3.89	498.0	0.00	-3.71	0.00
24+*	3.72	4.37	497.5	0.00	-3.28	0.00
25	2.39	2.84	417.0	0.16	-1.73	0.09
26	2.61	2.89	397.0	0.30	-1.24	0.22
27+*	3.11	3.68	489.5	0.00	-2.54	0.01
28+*	2.94	4.11	543.0	0.00	-3.99	0.00
29+*	3.78	4.16	433.0	0.07	-1.89	0.06

* indicates that means between the pre- and post-tests are significantly different;
+ indicates that medians are significantly different at the 95% confidence level, based on a two-tailed test.

Category Results: Computers (Pre versus Post)

Table 6 provides results for survey questions that specifically addressed computers. There were significant differences between the mean and median pre- and post-test survey responses for all five of the computer-related survey questions. After taking the class, students reported an increased comfort with their computer and file-management skills and with their ability to work with tables and databases (questions 30, 33, 32, 31, and 34). These results indicate the positive influence this course had on students' perceptions of their computer capabilities and documents the effectiveness of the GIS course in developing students' computer competency.

Table 6: Computer-Related Survey Questions Results

Question #	Pre Mean	Post Mean	Mann-Whitney W statistic	W-test p-value	t-test t-statistic	t-test p-value
30+*	3.61	4.26	450.0	0.04	-2.31	0.02
31+*	3.39	4.16	478.5	0.01	-2.76	0.01
32+*	3.83	4.32	456.0	0.03	-2.29	0.03
33+*	4.22	4.63	433.0	0.07	-1.96	0.05
34+*	2.92	3.42	448.5	0.04	-2.12	0.04

* indicates that means between the pre- and post-tests are significantly different; + indicates that medians are significantly different at the 95% confidence level, based on a two-tailed test.

Category Results: Community (Pre versus Post)

Table 7 provides results for survey questions that specifically addressed community. Mean and median responses between the pre- and post-tests were statistically significantly different for five of the six questions (using a two-tailed test). These results indicate that after having taken the GIS class, students perceived that they were more knowledgeable about their community, were able to work with community-related data, and had the skills to contribute to busi-

Table 7: Community-Related Survey Questions Results

Question #	Pre Mean	Post Mean	Mann-Whitney W statistic	W-test p-value	t-test t-statistic	t-test p-value
35+*	3.00	3.67	439.5	0.03	-2.46	0.02
36+*	2.58	3.16	451.5	0.04	-2.19	0.03
37+*	3.03	3.74	474.0	0.01	-2.67	0.01
38+*	3.53	4.00	406.0	0.10	-1.84	0.07
39+*	3.64	4.05	434.5	0.06	-2.03	0.06
40	3.14	3.47	414.5	0.17	-1.41	0.16

* indicates that means between the pre- and post-tests are significantly different; + indicates that medians are significantly different at the 95% confidence level, based on a two-tailed test.

nesses within their community (questions 36, 35, 37, and 39). These results indicate the effectiveness of the GIS class in raising students' awareness of their community.

Conclusions

Results indicate the positive influence that this particular GIS course had on students' perceptions of geography, their GIS and computer competencies, and their relationship to their local community. Results indicate that, as a result of this course, participating students developed an understanding of connections between geography and GIS, enhanced their computer skills, and developed significant insights into their community. The goal of this course was to develop GIS and computer competencies, and connect these skills to geographic knowledge and community applications. Results indicate that these goals were met.

The success of this course suggests that GIS can be used as a mechanism to integrate geography training with technology standards. This project demonstrated the value of a high school GIS elective and also provided a model that high school faculty can use to develop a high school GIS elective. A high school GIS course not only can increase students' technology competencies but can raise awareness of geographic concepts, increase geographic knowledge, and instill in students an understanding of their local community and their role within their communities. The recent interest in integrating computer technology into high school curricula can be well-served by a GIS course. In doing so, students would be exposed to geography through GIS and computer technology, thus bringing geography back into the classroom in a compelling way.

This case study identified the administrative steps taken to institute the course, provided a course outline that can be used by high school faculty, and quantified the learning impact of such a course. Some of the supports for the implementation of GIS in a high school setting were addressed, specifically the need for hardware, software, and administrative sanction. The course development and implementation process was carried out by a GIS professional, not a high school faculty member. High school faculty who may not have the preparation to teach GIS would have to take time to familiarize themselves with the software and the course lessons prior to implementing this model. The barrier of requisite faculty time for GIS preparation is one that still must be overcome for successful integration of a high school GIS course before the demonstrated benefits can be realized on a larger scale. Schools must be receptive and supportive of computer technology, hardware, and software. Teacher preparation programs could integrate GIS as a component of pre-service training requirements so that modules such as those used in this course would then be readily accessible to high school faculty.

References

Benefiel, A. 1995. Introduction to Geographic Information Systems: Laboratory Notes. Bend, OR: Central Oregon Community College.

California Department of Education. 2004. Content Standards. http://www.cde.ca.gov/be/st/ss/index.asp (last accessed 9/7/04).

Environmental Systems Research Institute (ESRI). 2004. ArcLessons. http://gis.esri.com/industries/education/arclessons/arclessons.cfm (last accessed 9/21/04).

Guiterrez, M., B. Coulter, and D. Goodwin. 2002. "Natural Disasters Workshop integrating hands-on activities, Internet-based data, and GIS." *Journal of Geoscience Education* 50(4): 437–443.

International Society for Technology in Education (ISTE). 2004a. National Educational Technology Standards (NETS). http://cnets.iste.org/ (last accessed 9/20/04).

International Society for Technology in Education (ISTE). 2004b. National Educational Technology Standards for Students. http://cnets.iste.org/students/s_stands.html (last accessed 9/20/04).

Kerski, J. 2003. "The Implementation and Effectiveness of Geographic Information Systems Technology and Methods in Secondary Education." *Journal of Geography* 102: 128–137.

———. 2001. "The Implementation and Effectiveness of Geographic Information Systems Technology and Methods in Secondary Education." *ESRI User Conference Proceedings.* San Diego, CA. http://gis.esri.com/library/userconf/proc01/professional/papers/pap191/p191.htm (last accessed 9/21/04).

———. 1999. "A Nationwide Analysis of the Implementation of GIS in High School Education." *ESRI User Conference Proceedings.* San Diego, CA. http://gis.esri.com/library/userconf/proc99/proceed/papers/pap202/p202.htm (last accessed 9/21/04).

Lander, R. 1999. *AuThenTiCITY: Youth Mapping Community Solutions*. Phoenix, AZ: Education and Youth Programs Office, City of Phoenix: 11-1 to 11-26.

Mackaness, W. 1994. *Curriculum Issues in GIS in K–12*. GIS/LIS Conference, Washington, D.C.

Malone, L., et al. 2002. *Mapping Our World*. Redlands, California: ESRI Press.
Meyer, J., J. Butterick, M. Olkin, and Z. George. 1999. "GIS in the K–12 Curriculum: A Cautionary Note." *Professional Geographer* 51(4): 571–578.
National Center for Geographic Education (NCGE). 2004. The Eighteen National Geography Standards. http://www.ncge.org/publications/tutorial/standards/ (last accessed 9/9/04).
National Geographic Roper Survey. 2002. http://www.nationalgeographic.com/geosurvey (last accessed 9/7/04).
National Geographic. 2004. The National Geography Standards. http://www.nationalgeographic.com/resources/ngo/education/standardslist.html (last accessed 9/9/04).
National Science Education Standards (NSES). 2004. http://www.nap.edu/readingroom/books/nses/html/ (last accessed 10/25/04).
Personal Communication with Lakewood High School Faculty Members (Myles Loveall and Stephanie Bauer), August, 2004.
StatGraphics Plus for Windows Version 3.3, 1997. Manugistics, Inc., 2115 East Jefferson St., Rockville, MD.
Woodward, K. 1999. *Alignment of National and State Standards: A Report by the GED Testing Service*. Washington, D.C.: General Educational Development Testing Service. 341 pp.

Acknowledgments

We appreciate the cooperation and commitment of ESRI and the administration, personnel, and students at West Covina High School. We thank the anonymous reviewers for their helpful suggestions.