"Creating Community: University of Texas at Austin and Local Schools"

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Abstract:

With funding from the National Science Foundation’s GK-12 Program, The University of Texas at Austin is partnering with local schools to develop innovative learning activities combining natural and social sciences. GIS is a critical tool in this initiative. Using a wealth of free municipal, state, and federal GIS data and digitized historical maps, students engage in cross-disciplinary activities. These include the analyses of current environmental and social conditions, explorations of historical growth patterns and their impacts on critical natural resources and biodiversity. Activities are carefully designed by graduate students teamed with middle school teachers to meet Texas state educational standards.

Acknowledgements

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Introduction

Effective education involves engaging curriculum that spans across multiple disciplines and is relevant to the students' lives. In seeking to develop innovative teaching methods and learning activities to integrate social and natural science education at the middle school level, faculty and graduate students at The University of Texas at Austin collaborated with four Austin-area teachers. Classes involved included 6th grade Integrated Science and 7th grade Texas History. The overall theme of the various activities was to study the environmental and social impacts of urban development, using Austin and Central Texas as the case in point. There are many contentious issues in urban growth, and these frequently top the news in Central Texas where growth is occurring rapidly over an important aquifer. We wanted students to understand the science behind the issues, be aware of the political values and policies in play, and comprehend that development is the result of many complex choices made in the public and private realms. Class projects involving Geographic Information Systems (GIS) provided a critical interdisciplinary link that allowed students to visualize relationships in their own neighborhoods and their city.

The integrated use of GIS with a suite of other classroom and lab activities, rather than GIS being an end in itself, was a key objective in this program and a critical factor in its success. Learning activities that supplemented the GIS component of the project included exercises for hands-on learning such as experiments to measure porosity and permeability of local soils, an exercise that had students build a topographical model of the original Austin town site from 1839, and an analysis of the environmental and economic impacts of suburban "big box" development. Another key success factor for the project was the availability of free local data sets, including aerial ortho-photography that could be downloaded from the City of Austin and other government agencies. The project thus highlighted the benefits that can be attained when a national research funding program, a major university, local schools, and local government work together in the classroom. Although the project was not intended to be a demonstration project for GIS use in local schools, it generated enormous enthusiasm among teachers and students. The Austin Independent School District had maintained a district site license to GIS software for several years before letting it lapse due to lack of use. The success of this project has inspired participating teachers to work towards renewing school district interest in supporting GIS in the classroom.

NSF's GK-12 Program at The University of Texas at Austin

The National Science Foundation funds the Graduate Teaching Fellows in K-12 Education Program, abbreviated as GK-12. This program is one of NSF's cross-disciplinary programs, aimed at "improved communication and teaching skills for the graduate student fellows, enriched learning by K-12 students, professional development opportunities for K-12 teachers, and strengthened partnerships between institutions of higher education and local school districts" (National Science

Foundation 2004). The University of Texas at Austin has just completed the second year of a three-year initial grant under this program. Each GK-12 graduate student fellow is assigned to two teachers to collaborate on activity development, serve as a subject-area resource, and to learn about the challenges and opportunities of teaching K-12 students. Three UT Austin institutes participate in the grant: the Environmental Science Institute (ESI), the Marine Science Institute (MSI), and the Institute for Geophysics (UTIG). During the first year, geographic information systems technology was used in a few classrooms. In the second year, the Environmental Science Institute secured supplemental funding to add a social sciences component to the GK-12 program and the use of GIS began in earnest. The co-principal investigator for the social science supplement is a professor in urban planning, and the proposal focused on using current and historical maps and spatial information as a basis for exploring the complex interplay between environment and urban growth (Environmental Science Institute 2004). This focus built on the ongoing theme of ESI's GK-12 program which focused on studies of the Edwards Aquifer, an important groundwater source that runs underneath portions of Austin and supplies water to many people in the region, including the entire city of San Antonio.

One graduate student in urban planning was chosen to work on the social sciences portion of the project with a natural sciences graduate student in geography. The graduate students teamed with science and social science teachers to plan activities that were interdisciplinary and taught science and scientific methods of inquiry. These activities also had to meet the State of Texas educational standards (called TEKS or Texas Essential Knowledge and Skills) and fit with existing curricula goals and demands.

Setting up the projects for GIS use

We knew that GIS would be a foundational tool in the project just as it is in the professional world of urban planning. GIS strengths include data collection, compilation, analysis, and visualization of information, and there is hardly any issue in urban development that is not in some way spatial. The co-principal investigator's previous experience with GIS use with K-12 teachers and students showed that the use of local area data could generate high enthusiasm and interest on which to build other activities. In particular, young people love to see their own house and school in aerial photos. The ability to bring up these photos with other local GIS layers then leads the students to seeing other relationships and asking more questions. The co-principal investigator has also used historical aerial photos and scanned maps in GIS within the K-12 and public environment. Again, once students have seen their house they are keen to see what it looked like before it was built, and to start literally and intellectually "zooming out" to the wider region and wider connections. Without local data, and especially aerial photos, this initial personal connection is difficult to make, and activities become more abstract.

The City of Austin (COA), the Capital Area Planning Council (CAPCO), and the Texas Natural Resources Information System (TNRIS), a state agency, all provide free download access to detailed local GIS data sets. In particular, CAPCO provides access to 1997 and 2002 ortho-photos, and TNRIS provides access to statewide digital ortho-photo quarter quads from the 1995 and 1996. The latter data set makes an excellent base for examining areas before the economic boom of the late 1990s which brought very rapid change to many Texas metropolitan areas. The city of Austin has comprehensive infrastructure, facility, and environmental data sets. These local data sources are largely unknown to local K-12 teachers, however, and in the case of the city of Austin, their online organization is difficult to understand and navigate. Users have to have worked extensively with the data to know where to get it and what it represents. Also, although schools have online access, their internet connections are often slow. We therefore decided to create our own CD of the local data sets for easier use by teachers and students.

Our goal was to create learning activities that could be used or adapted easily in other schools in the Austin area. A second preparation issue thus involved the choice of software, and what might be the most widely available. We found no good solution to this issue. Ideally we would like to have schools using the most recent software. The Austin Independent School District no longer supported an ESRI site license and did not have access to Arc 8x. Even if they could get access, many of the school computers did not have the required RAM and other components to run the newer software. Individual schools did hold older single licenses of ArcView 3.2. In addition, we knew that schools could acquire ArcVoyager, specifically created for the K-12 environment, and could download viewers like ArcExplorer. We were not sure of continued availability of these programs, however, and in the end we decided to develop activities based on ArcView 3.2.

Initial GIS instruction focused on how to create a map in ArcView 3.2 and covered most of the fundamental uses of the software. With the students' enthusiasm stoked by the use of local data, they quickly mastered these basics. Other activities built on this foundation and did not require detailed instruction in advanced software capabilities. This point is important – we didn't want to be teaching GIS as much as we wanted to be exploring the impacts of urban development on the environment (specifically the aquifer) and the local economy. We used GIS as a tool to pull spatial information together and to visualize local and regional information. Other activities built on this framework.

The rest of the paper describes example activities related to learning about the hydrology of aquifers and the relationship to urban growth, the historical evolution of Austin as part of Texas history, and the phenomenon of “big box” development from both an environmental and economic perspective.

Covington Middle School

One of the schools involved in ESI’s GK-12 Program for the school year of 2003-2004 was Covington Middle School (CMS). Located in South Austin, CMS is ethnically and economically diverse. Just over half of the students are members of an ethnic minority group and nearly a quarter are economically disadvantaged (Texas Education Agency 2003). Many of the students that we worked with were bilingual in languages such as Spanish and Vietnamese. Based on a survey of the seventh-grade Texas History students, almost half of the students do not have computers at home.

CMS does have a computer lab, but like many other schools, it has technical difficulties that must be overcome. Not all of the 32 units worked at the same time (there were always at least three out of order). As a result, we often had to pair students together at a computer to work on a project. Secondly, because of space limitations on the computers, we were not able to adequately save all of the students’ work. Finally, all of the teachers shared the 32 units, which meant that teachers had to pre-book the lab at least a month ahead of time to obtain a one-week period of uninterrupted class time in the computer lab.

Working in an environment like this might have been discouraging if the campus was not completely welcoming of our project. We had great support from the administration including the principal, vice-principals, and teachers, who all took part in the project at some level.

Whether it was helping us get more paper or assisting in circulating around the lab, it was a community effort to successfully implement GIS technology in the classroom.

GIS is becoming a key technology to support decision making. In previous years, much money was spent for AISD to have the site license necessary for GIS, but it was not used because the teachers did not know how to use it with their students and because they were largely unaware of the abundance of free local GIS data. The introductory PowerPoint presentation, along with the GIS lesson plans and instructions provided by the graduate fellows, enabled teachers to use GIS with their students.

Creating the Natural Science / Social Science Connection

One of the initial questions we approached before engaging in this project was how to integrate science and social science disciplines in the classroom. Through conversation we discovered overlap in the following four areas:

1. Use of maps
2. Interpretation of charts and reading of graphs
3. Communication with illustrations or images
4. Scientific reports

We decided the best approach was to use maps as the basis for integration across-disciplines. This included a two-tiered approach that started with basic map reading and cartography skills in the sixth grade extended to higher-level GIS use in the seventh grade. In order to integrate the maps through both disciplines, the teams decided to focus on the environmentally sensitive aspects of the city including the Edwards Aquifer. Through a two-year vertically-integrated project (6^{th} grade science students then going into 7^{th} grade Texas history classes the next year), students would learn about the scientific properties of the Aquifer and the implications of future population growth and public policy in Texas.

Level 1: The Sixth Grade Learns about the Local Environment

Surface-Groundwater Interactions and Community

Units of study on Surface-Ground Water Interactions are often weakly developed in middle school curriculum and frequently do not incorporate relevancy to the local community. To remedy this problem, an entire month's worth of new, innovative lesson plans that are both engaging and continuously inter-related were created through collaboration among GK-12 teachers, graduate students, and professors from the University of Texas at Austin. In the first part of the project, students were provided with an appreciation of their surrounding environment by teaching them the importance of local water resources and the current practices that threaten these resources.

The students learned about surface-groundwater interactions, which is in the forefront of scientific research due to its tremendous impact on our community and environment. It is important for students to know that how we live on our watersheds impacts water quality. Students studied watershed systems, why groundwater is important and who depends on it, the parts of an aquifer, features of karst topography, the formation of sinkholes and caves, porosity and permeability, the impact of impervious cover, where Austin gets its drinking water, demand for water in relation to population growth, endangered species of the Edwards Aquifer, point source and non-point source pollution, and what students can do to help keep our watersheds and aquifer clean. These lessons increased their previous knowledge base, gave students a clearer understanding of the importance of the Edwards Aquifer, and related to previous knowledge of the water cycle and rock formations. Before these lessons, the students did not know that they lived in a watershed, and they thought that the Edwards Aquifer was something "down the street" (that is where they see the signs). The students were interested in learning where they lived in relation to the Edwards Aquifer (something directly relevant to their lives), and they were excited to discover that they live in a watershed that overlaps with the Edwards Aquifer.

Hydrology Labs

To gain further understanding of surface-ground water interactions, the students conducted hands-on experiments to measure porosity, permeability, and chemical changes in water that moves from the surface into an aquifer. In the porosity and permeability labs, students compared the porosity and permeability of local sand, gravel, and topsoil. Before beginning the experiment, students hypothesized which material has the highest porosity and which is the most permeable. The students recorded their data in a table to compare results. These hands-on labs were an excellent way to engage the students in learning the lesson.

In the last hydrology lab, Solubility and Chemical Change to Groundwater, students measured the change in pH before and after acidic water traveled through two different types of model aquifers: one of igneous pebbles and the other of limestone. We wanted the students to learn how soluble materials can enter the ground water and sometimes even cause chemical changes (such as pH). After formulating a hypothesis, the students poured diluted hydrochloric acid through their model aquifers. The students tested the pH of the diluted hydrochloric acid before and after it traveled through the aquifer to determine if a change in pH occurred. This lab enabled students to understand that chemical change can occur even when no visible change takes place. This provided an excellent opportunity to discuss unseen pollution. These labs have definitely changed the way students think about sources of water pollution and what should or should not be done in a recharge zone. The students brainstormed possible solutions to water pollution, including specific ways that they can make a difference.

In the next phase of the unit, GIS enabled students to expand their newly learned hydrological knowledge into a larger spatial context. In the first GIS lab, students located parks in relation to the Edwards Aquifer. The students utilized City of Austin GIS data to answer questions such as how many acres a particular park is or what parks are on top of the Edwards Aquifer. The students were intrigued by being able to manipulate the program, give it a different look by changing the colors or symbols, and identify something with the identify tool and find out information about a theme by opening the theme table. Overall, they enjoyed exploring the many tools and applications of GIS. As a whole, the students did an excellent job - as well as college students in an introductory GIS course. It is encouraging to think about what these students could be capable of doing with GIS by the time that they are in college.

GIS provided students with an opportunity to view data in a new way. In GIS, data tables are connected with something visual, which may give students a better understanding of charts, graphs, and tables and improve their ability to interpret them. Having detailed written procedures, talking the students through the complicated steps, and encouraging students to help each other facilitated meeting the lesson objectives. There was no wasted time. If students finished early, they tutored others or explored additional layers of information. With the students thoroughly engaged, there were no behavioral problems.

In the next GIS lab, students created a new layer that represented watersheds that overlap with the Edwards Aquifer by intersecting two themes (Watersheds of Travis County and the Edwards Aquifer) with the GeoProcessing Wizard. They then changed the legend type to unique value in order to view all of the watersheds on top of the Edwards Aquifer as separate entities. They followed all of the necessary procedures to create a map of Watersheds of the Edwards Aquifer of Travis County and included essential map components such as a title, legend, scale bar, north arrow, cartographer, and publication date.

In the final GIS lab, students used knowledge they gained in the previous labs to create their own map of the Austin Area. They investigated layers to determine what information they wanted to convey and what type of map they wanted to create. The students were excited about having the freedom to create their own product, explore the layers, and make the decisions about what their map was going to look like. They chose what they wanted their map to represent, which layers to use, and how to manipulate the themes. They determined how to layout essential map components, decided an appropriate title, and exported and saved their map as a jpeg. They were able to produce a new product and hence, call themselves cartographers. The most effective part of this lesson was that it required the students to utilize the knowledge that they have accumulatively acquired throughout the Edwards Aquifer GIS Lab Series.

“Big Box Development” Debate

The finale of the unit was the debate on “big box” development over the Edwards Aquifer, which is currently one of the hottest public policy issues in Austin. “Big box” refers to large chain outlets characterized by much larger square footage than traditional stores in the same market sector, often on the scale of 100,000 square feet or greater. These are typically accompanied by parking lots designed to hold near maximum customer capacity. The students spent two days researching the pros and cons of "big box" development and organizing their debate. Then, students took turns presenting their argument. In advance, the students were given a sheet that listed requirements of a good debate and a debate organization chart that helped them outline their Argument Plan. They conducted research and read articles, and some students even interviewed experts and conducted surveys to broaden the pool of their sources. The students practiced good debating skills such as having an organized presentation, supporting their evidence by fact and citing their sources, utilizing illustrations and charts, and being prepared for a thorough rebuttal. They were so involved in the debate that they did not want to stop. Students were able to compile and translate what they had learned throughout the Edwards Aquifer GIS Project to higher level thinking and look at the impact of a real-world situation on their community.

Level II: The Seventh Grade Continues Education through Community Awareness

While the sixth graders worked on their hydrology labs, the Social Science Fellow continued to work with 7th graders in the Texas history class. Our goal was to provide cross-disciplinary, vertical alignment that would create a specific skill set in the sixth grade that could provide a base for the activities in seventh grade. This year there was one challenge: since this was our first year, the seventh graders did not have the introduction to basic cartography. In order to provide the same background, we approached both grades with the same introduction to cartography and GIS. However, the seventh grade students had to complete additional assignments to prepare for their GIS projects. With the seventh grade students, our goal was to make the connection between past and current growth trends, and environmental issues in an effort to show how history is relevant to contemporary public policy problems.

In order to help 7th grade history students improve their understanding of the relevance between history, their community, and the local environment, we took a three tiered approach to help them make the connection. First, students read traditional history books and were introduced to research in primary resources. Second, using information they had researched, students built a physical model of the study area. Third, they replicated model attributes using GIS and compared historic boundaries with modern city limits. Using the environmental perspective as the lens for examining our community, students studied everything from historical maps and indexes to the scientific definition of an aquifer, with a final step of working in GIS.

Step #1: Understand the local environment in the site selection of the capital.

Austinites, even the young ones, are proud of the environmental quality of their community. However, when approached with the questions regarding the type of environment that existed in Texas in the early 1800s, most students could not make the connection between the local, physical environment and the decisions made by settlers to build their homes in the area. In order to improve understanding of the historic connections between early settlers and the modern Austin population, the teacher-fellow team used a series of primary resource documents from early expeditions to the area in order to have students identify why settlers chose this site as the capital of Texas. Students were asked to read material beyond their grade level; not only did they do well, some enjoyed the process. In addition to defining the basic characteristics that made site selection of early Austin favorable, students were asked to define the value system of early settlers and compare it to their own. For example, they were able to discern that access to water was a primary objective of a settler selecting a home site, while now; the main concern of a new family might be access to a good school. By reading early texts from the discovery expedition and its role in the selection of the capital site, students had an improved understanding of how politics between leaders and scientific information are used in the public policy-decision making process.

Step #2: Examine the local topography of the community and recreate a representative model

After students had an improved historical understanding of site selection and the environment of the early capital of Texas, we asked them to recreate the area in a model. In order to help them relate the small size of the original site to present day Austin, the Social Science fellow created an image using the original borders of the Waterloo site (originally a fifteen block radius) to compare to the present day street boundaries of the City of Austin.

Using GIS software, a topography shapefile, and street layers, the Social Science fellow created a basic map 36x42 inches and divided the map into four quadrants. The class was divided into four basic teams; each team was responsible for recreating one quadrant of the original Waterloo site using wallpaper paste and shredded newspaper. After building the map and painting it the various shades of green, yellow, and brown, students were asked to recreate creeks and rivers with latex plastic.

The teacher-fellow team divided the students again to research other characteristics of the area including native trees, flowers, animals, the layout of the first buildings in the capital, a replica of the capitol building, a replica of the Governor's House, and early streets. After about seven days of research, planning, and building, students had a more thorough understanding of the early capital and could more easily conceptualize the area and its attributes. Additionally, their work was a great source of pride for the students as the topography map had turned into a little city.

Completing the model encouraged students to conduct original research on historic Austin. Through their own initiative, students had to identify appropriate resources, independently research their topic and use group consensus to draw out the most important aspects of their research. As a part of the process, they were required to make presentations to the class, which were open to questions from classmates as well as the teacher and Social Science Fellow. Finally, working in their teams and with other groups, students had to agree on how to represent their findings on the original map and the legend.

Step #3: Take students to the computer lab to learn about GIS and its many uses in public practice

Taking the advice of one of the seasoned teachers with whom we were working, the two graduate fellows used the same approach with sixth and seventh grade in order to find out how these two groups of students worked. With both classes, the project began with a day of pre-lab instruction. There were two ways GIS software was introduced in class during the same period. In order to maintain the structure of the classroom, the class began with a brief PowerPoint® presentation that defined GIS and demonstrated its uses in the real world. The purpose of the presentation was twofold. First, students were asked questions to evaluate their level of understanding regarding basic cartography. This allowed for the fellow-teacher team to have some preliminary evaluation benchmarks. Secondly, the lecture served as exposure to maps and what GIS actually looked like on the computer screen in order to dissipate student anxiety. The presentation contained a variety of images including a street and topographic maps similar to the ones that would be required by the students.

Once the lecture was completed, the class trekked to the computer lab and was handed a worksheet that allowed them to map on a computer using MapPoint® software. Though the lesson did not directly use GIS, it did help accustom the students to mapping on the computer while offering additional evaluation of their skills in the classroom. Results varied widely, some students completed the worksheet in as little as five minutes, while others used the entirety of the period. As the first students finished, they were asked to circulate in the classroom and assist their peers. This exercise was incredibly useful because it assisted the Fellow in evaluating student computer skills and it established computer lab structure with behavior expectations, a crucial component to success in middle school.

Over a period of about seven days, students worked diligently on a variety of GIS activities. Like the sixth grade students, the seventh grade students were given an introductory PowerPoint® presentation and examined Central Texas watersheds over the Edwards Aquifer through GIS mapping. With both grades, each class also started with basic instructions in the lab and a computer projection of a student's activity in order to remind students of how to access files and data. In addition to this, the seventh grade students had a series of higher-level thinking activities. Unlike the other classes, the seventh grade students worked on an exercise to determine whether parkland allocation was sufficient for the local population, a project that required students to use aerial photos to draw a comparative analysis of how present day downtown Austin has changed from the historic model they created, and a worksheet that helped students calculate amounts of impervious cover and discuss the effects of groundwater pollution. The final project consisted of them creating their own rubric for a map and then creating a map to fulfill the major criteria "create a map to demonstrate a public policy problem in Austin". We were astonished at the results. While most students examined basic problems, such as a lack of circulation infrastructure in Southeast Austin, one student decided to examine gas pipelines near local schools and another student created a wonderful map that demonstrated hazardous materials sites over the Edwards Aquifer. The most impressive part of this process was the questions they asked, not us, but each other. By the end of the project, students had initiated their own discussions and were using GIS to help make their own community connections.

Conclusions

Despite the initial challenges we faced in undertaking this project, we were able to show that vertically aligned connections could be made between natural science and social science disciplines. GIS proves to be an effective tool to build a bridge that can link multiple disciplines. However, in order to have GIS work well in the classroom, we discovered the following:

1. **Pre-lab activities facilitate a successful transition to GIS**

   Pre-lab activities proved critical to the successful use of GIS. They provided students with background information, complemented by a variety of visual images such as showing maps and computer screens, which was absolutely necessary to prepare students for GIS. It was extremely effective for the 6^{th} grade students to study local maps and learn the background science behind the GIS information layers before starting the GIS labs. The seventh grade did not receive as much introduction as the sixth-grade students. The results included more frustration and apprehension for seventh-graders in the computer lab and more problems setting up students on the first day. In hindsight, the seventh-graders should have received a more comprehensive introduction to the GIS project that included a review of even the most basic computer skills, including how to start, print, and save their files. Additionally, we found that connecting a projector to a student's computer while they worked coupled with teacher instruction was a necessity each class period to remind students of what steps to take in the process.

2. **GIS should be implemented in a multi-year project**

The largest impediment to the successful implementation of all the projects we wanted to undertake was a shortage of time. This was realized as we discovered the wide discrepancy in student skill level. We knew we did not have the luxury of bringing all the students up to the same level, so we decided the best way to approach this was to target specific skill sets and designate them to a grade level. For example, the introduction to cartography and GIS would occur at the sixth grade level, while use of ortho-photos and creation of other higher-level maps would happen in the seventh grade. By implementing GIS as a multi-year project, a foundation can be built to provide the students with the necessary knowledge and skills for an intensive GIS learning experience.

3. **Ideally, there should be one or two students per computer**

Initially, we asked the computer lab technicians to install the software on each computer, but about nineteen units were ready to accommodate twenty-seven students. The first part of the week we doubled-up students on units. This worked well until we began to use ortho-photo files. Some of the files crashed computers, which forced us to triple students on a unit. Though not a complete disaster, this certainly did not provide the best working environment and was a source of much angst in the final evaluation. A ratio of one computer per student would be best because it allows for every student to practice their skills, allows allow the teacher to evaluate performance based on individual accomplishment, and facilitates project storage. However, if there are limited computers available, we found the best way to work above those limits was to pair students, provide each student with a worksheet to turn in at the end of the period, and have students trade responsibilities each day.

4. **Students should be allowed to provide support to each other**

A student serving as tech support in the classroom is another invaluable resource to teachers. Student assistance in the computer lab increases the level of responsiveness to student questions and improves the ability for students to relate to each other and the teacher. Students of the 6^{th} and 7^{th} grade classes were eager to help each other out. As a result, we quickly saw students take the lead in helping the class finish the assignment and help in everything from computer troubleshooting to helping save and print files. Most importantly, the student assistants more confidently critiqued our instructions and worksheets.

5. **Several adults should be circulating in the classroom**

While tech-savvy students provide a high-level of peer support in the classroom, their authority is limited in the view of other students. It does not necessarily matter that all the adults assisting know how to use GIS. More adults in the classroom provide additional student supervision. Whether it is helping students receive print jobs or monitoring student access to the internet, extra adults are extra hands in the classroom. From our experience, we found at least two adults were necessary in the computer lab: the first to provide instruction at the front of the class and the second to walk around and watch the monitors on the computers to help the class keep pace. For classes larger than 25 students, a third adult may be needed.

6. **There should be a variety of storage devices available**

The biggest challenge for our classes was deciding how the students should store their map products. The sixth graders, who were taking Introduction to Computing, had an easier time than the seventh graders, who had forgotten much of what they learned the previous year. As a result we had to take two approaches. The sixth grade students and some of the seventh graders were able to save to their student folder on the school server. However, one problem with to having students save products in their folders was that computers did not have any software for reading image files; having students export files as .jpgs was futile. Instead, we had students save maps in the standard GIS .mxd file for future reference. For those students that could not save in their student folder, we saved maps on a flash drive. Finally, to facilitate grading, we asked students to print their map for submission to the teacher.

7. **Students should be encouraged to present their findings**

While most students are comfortable and confident in their work on the computer, we found that not many in the seventh grade case were comfortable making presentations in the classroom. However, in casual conversation when students were questions regarding their findings, their answers were quite insightful. Even though we touted GIS as a communication tool, we did not reinforce this with a lesson requiring its use in a presentation. In hindsight, we should have reinforced the use of GIS with a presentation requirement for the seventh graders.

8. **Local data should be used**

Using local data in GIS Projects increases student interest level and engages them in learning relevant information about the relationships between their community and surrounding environment.

The GIS project at Covington Middle School was a wonderful success. Not only was it enthusiastically received by the teachers and administration, but it was given high marks by the students as a worthwhile and fun project. The successes of this project can be attributed to the ability of GIS to integrate natural and social sciences; the use of local data to engage students in learning about their environment and community; and partnerships established through the GK-12 Program that encouraged collaboration among university professors, graduate students, and K-12 teachers. We hope that the experience gained in this project will promote future integration of GIS to further enhance K-12 curriculum.

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Appendix A: Summary List of Lessons Created 2003-2004 School Year for the GK-12 GIS Project

Please Note: These will soon be made publicly on the UT-Austin Environmental Science Institute GK-12 Website, available online at http://www.geo.utexas.edu/esi/gk12

GIS Labs

1. “Mapping with Mappoint®”
2. “Creating a Simple Map with GIS”
3. “Mapping the Edwards Aquifer Watersheds”
4. “Parks, Hydrology and the Edwards Aquifer”
5. “Problem of Parks in Austin”
6. “Using Digital Ortho Quarter Quads in GIS”
7. “Calculating Impervious Cover over the City of Austin”
8. “Viewing Population: Using the U.S. Census in GIS” (not classroom tested)
9. “Final Map Project Rubric”

Hydrology Labs

1. “Porosity Lab”
2. “Permeability Lab”
3. “Solubility and Chemical Changes to Groundwater Lab”

PowerPoint Presentations

1. “Surface-Groundwater Interactions” PowerPoint
2. “Solubility and Chemical Changes to Groundwater” PowerPoint
3. “Geographic Information Systems (GIS)” PowerPoint

Appendix B: Sample Lesson, Mapping with MapPoint®

Objective: Students will explore online mapping and learn the basic elements of cartography by using the MapPoint® website and the instructional worksheet

Time Allotment: 30-45 minutes, depending on the student

Engage: Start by asking the students the following questions:

1) What makes a "good" map?
2) What are the essential elements of a map?
3) How many of you have mapped online before?
4) How long do you think it is from *Address #1* to *Address #2*?
5) What are some landmarks or points of interest found in this neighborhood?

Exploration:
Asking students to work independently, distribute the worksheet while providing a time allotment for the activity. Reward students who finish early by letting them continue to explore the program on their own.

Explanation:
Students will follow the directions to map the distance between two distinct points. The questions on the worksheet direct the students to manipulate a variety of tools found similar to GIS. Some of these include the zoom, pan, enlargement, and identification functions. While playing with these functions, students are exposed to basic elements in cartography including the legend, compass, symbols, scale bar, and labels. Additionally, they should notice the use of map attributes, such as color, as a visual part of the map presentation. Finally, students should be able to identify at least one neighborhood element such as a street or park and should have at least an introduction to understanding distance.

Elaboration:
Students can alter their results by changing the address destination points. Additionally, they should be encouraged to use all of the tools in the program to manipulate the map, examining different program processes to learn to make and unmake mistakes with the software commands.

Evaluation:
If the students follow the directions exactly, they should arrive at the same distance between the two plotted points. The teacher may need to use their own discretion regarding grading. If a student manipulates the map too much before completing the worksheet, the final distance may be incorrect. To facilitate grading, advise students to complete the worksheet first, then allow them to explore the program.

Name:________________________
Period: ________

Mapping with Mappoint®

The purpose of today's lesson is to introduce you to mapping on the computer.
Please READ and FOLLOW THE DIRECTIONS CAREFULLY.
If you have a question, raise your hand and allow us to assist you.

1. **Double-click the Internet Explorer icon on your desktop**
2. **Enter the URL http://www.mappoint.com in the address bar of the window**
3. **Double-click on the "Maps" tab found on the right-hand side of the page**
4. **Scroll down to the blank fields under the "Find a Map" section.**

   Type in the following address:

   Address #1

5. **Hit the "Get Map" button**
6. **Using your mouse to direct the arrow, double-click on the boxes next to "Map Size" on the upper left side of the map. What does this do?**

   How does this help you view the map?

7. **Enlarge the map to the biggest size, click on the thumbtack in the middle of the page. What does this do?**

   Please list three streets South of the plotted address (this is the point where the thumbtack is located)…

   1.

   2.

   3.

8. **What happens if you click on the "OUT" button?**
9. **What can you see a landmark west of our plotted point? If not, click a few more times. What is the name of the landmark found to the west of our plotted point?**

Name:______________________
Period:_______

10. Scroll up and down the screen. Can you find the map scale? Draw what it looks like…

11. Click on the word "Legend" at the bottom right of the map. What is the name of the new window that is opened?

12. Using the legend select five different symbols found on your map? What do they look like? What do they represent? Draw in the table below:

Symbol	What does it represent?

13. Using the direction arrows, click on "North", "South", "East", "West"(these are located on the outside of the map frame). What happens when you click on these arrows?

14. Click on the words "To here" found on the right-side of the map. Enter the following address:

Address #2

Scroll to the bottom of the window. About how many miles is the trip? (You can round this estimate).

☺ Great job! Please raise your hand and we can pick up your work.

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