MAPPRINTS TO THE FUTURE!: MIDDLE SCHOOL GIS CURRICULUM ALIGNMENT

Session: Promoting Sustainable Use
Paper #1584

A Presentation Created for
ESRI EdUC Conference
San Diego, CA 2005

Authors:

Jennifer K. Lipton, PhD Candidate
jenlipton@mail.utexas.edu
University of Texas at Austin
NSF GK-12 Fellow

Nancy Poage Nixon
npoageni@austinisd.org
Covington Middle School
Science Instructor

Connolly Coyle
connollycoyle@hotmail.com
Covington Middle School
Science Instructor

Title: Mapprints to the Future! Middle School GIS Curriculum Alignment

ABSTRACT

Covington Middle School (Austin ISD) and the University of Texas GK-12 program are developing GIS-based, interdisciplinary curriculum that aligns both within and across grade levels. This allows teachers to build upon previously taught concepts and provides a unique opportunity to integrate both science and social studies curricula while developing advanced thinking skills. Sixth grade students utilize GIS software to locate, analyze and map their local watershed. This is augmented in seventh grade when students further develop their knowledge of GIS by jumping scales to examine Texas ecological zones. These same maps are also used in Texas History, thereby bridging seventh grade science and social studies curricula. Currently, a GIS curriculum is being developed for eighth grade that will incorporate local soils and geology. Upon leaving middle school, students will have utilized the advanced skills of GIScience to examine biological and physical science and analyze human development and social patterns.

Introduction

One of the challenges facing educators today is the ability to integrate interdisciplinary curricula with new technologies that will satisfy standardized testing requirements while developing and sustaining intellectual curiosity. At Covington Middle School (CMS), part of the Austin (Texas) Independent School District, a GIS-based curricula was designed for 6th and 7th grades that fulfills school district requirements and achieves horizontal transdisciplinary alignment between science and social studies courses. In a collaborative effort, CMS teachers and National Science Foundation's (NSF) GK-12 graduate student Fellows from the University of Texas at Austin devised 6th, 7th, and preliminary 8th grade lesson plans that incorporate educational requirements and themes of GIScience while broadening classroom inquiry learning. Formative intellectual development and inquiry is fostered at the middle school grade levels and the use of ArcView geospatial technology fits in naturally with computer literate and savvy, inquisitive youth of today.

The designed curriculum attempts to iteratively build upon concepts that are covered throughout middle school education while fostering a sense of place and community at various spatial and temporal scales. As part of this goal, the lesson alignment establishes at each successive grade level a multifaceted learning activity that engages students in scientific hypothesis development for project planning along with the technical skills required for use of GIS software. In 6th grade, students are laying the foundation for scientific inquiry by learning hypothesis statements and identifying variables. In conjunction with a GIS project, they gain the initial skill set necessary for data manipulation of local Austin datasets. In 7th grade, these skills are advanced to a higher level of inquiry by linking material across disciplines and through conceptual problem solving of statewide datasets. By the time the students arrive in 8th grade they are able to develop scientific hypotheses, formulate conceptual explanations, and use and analyze data to address questions. The 8th grade curriculum will then go one step further, using national and global datasets to develop students' aptitude for prediction making and identification of potential solutions.

In this paper, we will address the capabilities of ArcView GIS as an apt medium for developing inquiry-based learning at each middle school grade level. First, we will set the background on how collaborative transdisciplinary and institutional linkages are established between the Austin Independent School District and the University of Texas at Austin. Then, we will identify how GIS entered the curriculum and fits with the necessary requirements to be fulfilled in order to meet the State of Texas educational standards (also referred to as TEKS or Texas Essential Knowledge and Skills) as established by the planning guides for each grade level. Next we will describe how the GIS laboratories for each grade level and cross-discipline are designed, followed by the value of these datasets as a means to help situate students in their role in their local, state, and global community. Finally, implementation of this aligned curriculum will be addressed.

Collaborative Linkages

University of Texas at Austin and NSF GK-12 Program

The University of Texas at Austin Environmental Science Institute (ESI) applied for and received funding to be a part of the innovative National Science Foundation's educational outreach partnership program. The program, known as GK-12, creates a linkage between

institutions of higher education with public local school districts for grades K-12 by enabling graduate student fellows to collaborate with K-12 teachers. ESI initiated the program in 2001 and has successfully placed 14 Graduate Student Fellows in 11 different Middle and High Schools in the Austin Metro Area. Motivated educators from different school districts apply to participate in the GK-12 program to enhance the learning experience for K-12 students. In the second year of the UT at Austin NSF GK-12 program, there was a move to become transdisciplinary by attaining joint funding with a co-Principle Investigator faculty member from the Department of Urban Planning. This established a collaborative linkage between the Natural Sciences and Social Sciences and instigated an improved horizontal alignment between the curriculum of science and social studies teachers.

The partnership between all participants involved is mutually beneficial. Graduate students from different disciplinary backgrounds are placed in the classrooms working alongside the teachers and directly with the K-12 students. The graduate students assist in developing new materials and laboratory exercises with the teachers that incorporate new techniques, cutting-edge science, or methodological approaches that would be readily available to other teachers throughout the district. The graduate students benefit by developing better communication and teaching skills of scientific principles or methods. They also professionally develop by recognizing the value in outreach and in the collective teamwork effort that is necessary for inquiry-based education. Teachers benefit by collaboration with graduate fellows working within a specific science field. This connection updates teacher's strategies with the input of new technology and knowledge as the discipline of science progresses. K-12 students greatly benefit by being exposed to young researchers that are engaged in real-world scientific endeavors. In addition, the laboratory assignments or exercises that the teachers and graduate student fellows develop together offer new intellectual challenges and technologies. As a learning community, the fellows and the teachers interact together in a new way to exchange information and strengthen the opportunities for better course development in order to fulfill an overall goal of enhanced inquiry education.

Covington Middle School and the UT at Austin GK-12 Fellows

The ESI GK-12 program has been involved with teachers at Covington Middle School 2 years in a row. Covington Middle School is located in South Austin and maintains an economically and ethnically diverse student population of over 900 sixth through eighth graders. It is not uncommon for a science teacher to have a class in excess of 30 students with varying backgrounds, support systems, and learning styles. The teaching style is mostly interactive with a concentration on hands-on laboratories, question and answer, or team learning. Multimedia, computer-based classes are infrequent. The science classrooms are equipped with at least 2 functioning desktop PCs and there is a school computer lab available. The lab maintains 32 desktop units which all of the teachers in the school share. This requires planning a month in advance to reserve the lab for a week period of time. Students are able to logon with their own personal accounts and have access to the computers in the classroom during lunch periods or after-school.

Teachers and graduate student fellows have collaborated together in 6th grade Science, 7th grade Social Studies, and 7th grade Science classes. These classes include pre-advanced placement, on-level and inclusion students addressing all the different learning stages of visual, kinesthetic, and auditory learners. As collaborators we have found that this interdisciplinary and inter-

institutional linkage has been an advantage for new insights into higher-level learning. A comprehensive multidisciplinary approach is valuable because it instigates higher-level thinking and analysis and is the reason why a collaborative link between science and social studies is essential at this age bracket. At these grade levels it is not only where students begin the process of scientific inquiry and are asked to assess data, but it is also where young adults begin to identify themselves in a broader community. ArcView GIS is an important technology to be integrated into the curriculum because it prompts students to formulate questions, assess what data is necessary to answer these questions, provides a student-designed visual and investigative approach to exploring hypotheses, and produces a tangible result that requires proper and effective communication.

Curriculum Development

Science teachers are held to a prescribed set of learning standards determined by the State. The district further mandates that Earth System and Ecology process units be taught in 6th, 7th, and 8th grade science. Over a 4-6 week period teachers concentrate on the following topics: Earth systems, rocks and the rock cycle, the water cycle, groundwater and surface water, weather and atmosphere, ecological interactions within communities, and human impact. To satisfy the TEKS and prepare students for benchmark testing students should come out with an ability to understand patterns and processes, complex interactions of chemical and mechanical weathering, and an ability to illustrate through the use of models, maps or verbal communication the dynamic relationships that are taking place.

Alignment of curriculum at Covington Middle School was initiated during the first year that NSF GK-12 graduate student fellows were active in the classroom (Chapa, Gordon, and Parmenter 2004). The connection between 6th into 7th grade science and social science was a natural junction for curriculum alignment because of the overlap of skills and material covered. The importance of learning how to read and make maps, as well as interpreting information from graphs and charts, and then communicating this information was found to be a critical educational requirement at all levels.

The integration of ArcView GIS into the 6th grade curriculum built upon hands-on science labs that concentrated on surface-groundwater interactions, karst topography, water pollution and aquifers. This was particularly relevant and of interest to the Covington students because of the position of their neighborhood and local surroundings over the Edwards Aquifer. The project emphasized the importance of local watersheds and water resources, the impact of impervious cover and development on their neighborhood and the effects on hydrology. Hands-on experiments examining porosity, permeability, chemical and mechanical changes were conducted in the classroom with students hypothesizing possible outcomes, analyzing data, and recording findings. In conjunction with these experiments, the 6th grade students were then introduced to ArcView GIS in a week-long module using local Austin datasets.

The following year allowed for further development of GIS laboratories to be built-upon for 7th grade science and social studies courses using the previous infrastructure and themes that were established. Expanding the technology to additional teachers within the same school incorporated new lesson plans into GIS laboratory assignments. At the 6th grade level instruction is focused on introducing the translation of datasets into visual spatial data, which takes concrete

learning into abstract learning. This intellectual leap done in an interactive stimulating manner at the middle school grade level is instrumental in furthering educational goals. Once the 6th grade foundation of using ArcView has been set forth it is a natural progression to integrate higher-level thinking into the successive grade levels (see Fig.1).

Objectives

In 6th grade students manipulate GIS software and familiarize themselves with the program interface and commands. The student population quickly recognizes the symbols associated with loading, displaying data, and manipulating themes. This frequent manipulation of provided datasets enables them to create a required map illustrating local watersheds and their relationship to the underlying Edwards Aquifer. An outcome of this is that the students are able to define a unique problem by using the GIS Austin datasets to create their own map, which is a visual representation of their individual higher level thinking skills. This ownership of a quality end product expands their intellectual schema and instills the desire to further their own intellectual ambitions.

In 7th grade we jump scales and allow the student to visually interpret and manipulate statewide data. The students use ArcView to create maps and models representing distinct physiographic regions of Texas. Corresponding to 7th grade social studies curriculum students obtain better map skills, identify social patterns that affect environmental processes, and eventually create a map to demonstrate problems with Austin public policy. At the same time, students are using similar baselayer datasets and additional ecological data in their 7th grade science curriculum. Using these maps, the students then determine Texas ecoregions based upon ecological indicators, such as vegetation, climate, and topography. Extrapolating from the data students are better equipped at comprehending the role of ecological indicators in defining and characterizing the State of Texas.

At the 8th grade level, lab activities are currently under development that will broaden student perspectives by exploring human impacts on the environment. Students will use datasets to explore changes in resource availability, greenhouse gases, and global warming in relation to population centers on a national level. Students can also map centers of water pollution, air pollution, land use and industrial waste in order to hypothesize possible relationships between human activity and environmental processes. Urban datasets contribute to a broader understanding of how vital social science concepts and patterns are to understanding environmental processes. Using the combined knowledge gathered from analyzing social and earth science data enables the students in 6th, 7th, and 8th grade to understand their place in their local community. Once the student is able to situate themselves in the context of their local community they begin to have ownership. Acknowledging their local environment and personal jurisdiction through a spatially visual, scientific and analytical manner, students become more conscious of their impacts and role in civil society.

Design of GIS Exercises

Sixth Grade GIS Curriculum

The GIS labs correspond to the science curriculum of Earth Systems, and specifically water and groundwater processes. After completing hands-on labs, formulating hypotheses, and discussing the continued growth of Austin on the Edwards Aquifer, students are then brought into the computer lab to do ArcView GIS for one-week (or 5) 50 minute class periods. We feel

that the experience of performing the hands-on experiments and discussing the environmental properties and processes of the water cycle and groundwater recharge is critical prior to introducing the GIS component. It is through the kinesthetic experience that the students are then able to abstract the data variables and information that is visually communicated using the dynamic software capabilities of ArcView.

Local data sets were acquired from various state agencies and readily available online to download for free for the GIS exercises. Of particular importance and interest to these exercises were Digital Ortho-photo Quarter Quadrangles (DOQQs), aerial photos that have been ortho-rectified and registered with 1-meter resolution. The DOQQs were obtained from the Texas Natural Resources Information System (TNRIS) for the Covington neighborhood. The implicit value of these aerial photos is that students are able to immediately locate known features; such as, the school grounds, their homes, road networks, parks, and recreation facilities. This initial pattern recognition and geographic positioning allows students to rapidly situate themselves in context of other data sets and variables.

Addressing the curriculum topics of surface-ground water processes and human impacts, the GIS exercise requires students to map watersheds of the Edwards Aquifer in Travis County. The themes that are used include the following: the Edwards Aquifer, hydrology, watersheds, a county layer, city and state parks, schools, transportation networks, and urban infrastructure and facilities (ie. wastewater treatment plants, post office, health centers, etc.). Students are provided with step-by-step instructions on how to complete this operation. Students quickly and readily manipulate the GIS data and are involved in higher-level thinking when asked to create a map of the watersheds or facilities that are on top of the Edwards Aquifer. Using the ArcView Geoprocessing Wizard extension, they have learned how to explore their datasets well enough to know which themes they need to answer their questions. In addition, they become familiar with the Legend Editor in order to convey the data variables in such a way that adequately captures the necessary information.

Communicating the information effectively in a final map product is where the students are evaluated and able to express the inquiry-based thinking that results from the use of GIS in the classroom. The students follow a rubric that has specific components that they are able to focus on, identify and design their own question that engages their higher-level thinking and produces a tangible end product. The rubric has them create a title, specify the problem they are examining, list the layers that will be necessary to answer the problem, identify their data sources, and outline their procedures. In addition the rubric requests that they consider essential elements of cartographic design, esthetic concerns, and the overall presentation quality.

Seventh Grade Curriculum

The seventh grade GIS curriculum builds upon the foundational knowledge that was set out in the sixth grade GIS exercise and experience. The additional benefit is that there is alignment between the seventh grade science and social studies curriculum. Students integrate a critical thinking and analysis component into a GIS laboratory exercise focused on Ecology and physiographic properties. Students not only devise their own experiment, but also are asked to critically assess the variables and commonly accepted assumptions or generalizations. Additionally, students have now jumped scales from a local scenario (which was the concentration in the sixth grade GIS exercise concerning Austin and the Edwards Aquifer) to a statewide or regional scenario.

The exercise uses GIS software to map and model the physiographic regions of Texas based upon known indicators; such as, vegetation, precipitation, climatic regime, elevation, and geology. The labs are carried out over a week-long (or 5) 50 minute class sessions. Building upon the previous year's experience of working with GIS software, students are rapidly engaged in aspects of hypothesis solving because of their familiarity with the program. The retention rate of ArcView GIS techniques is fairly high after students become reinitiated in the software and computer savvy students are quick to assist one another in the process. In fact, it was found that the peer-to-peer teaching process developed a more rapid interest in the lab project, software and hypothesis exploration.

Students are asked to create their own Ecoregion map for the state of Texas using the GIS software and themes specified above. They use a visual assessment of the datasets and explore the layers by querying the vegetation, climate, elevation, hydrology and geology attributes. They are subsequently required to take the data that they have acquired and create a sketch draft of the maps, outside and apart from the layout capability of ArcView in the computer lab. We have found that at this age bracket the combination of computer and tactile reproduction of the data variables is an important aspect of retaining and critically thinking through the problems. In addition, this is done through a teamwork process that ensures that ideas are being communicated to one another and makes the learning activity a collaborative effort.

As part of the horizontal disciplinary alignment, students in 7th grade science are using GIS datasets to study Texas ecological diversity, while they are simultaneously learning about Texas settlement patterns and history in their social studies class. As part of their social studies curriculum they are making and using *papier-mâché* maps of Texas to locate important features and discuss historical events (Chapa, Gordon, and Parmenter, 2004). The multiple methods employed for teaching Texas geography, history and ecology draws upon visual, auditory, and kinesthetic learning styles, which is important for the variety of learners that are in enrolled in public schools.

The student-developed Ecoregion maps are then compared to an official Texas Parks and Wildlife Department State of Texas Ecoregion Map. Students are involved in critically assessing their map product, produced through analysis of GIS datasets and their own higher level thinking, with the official map. The comparative technique allows them to assess the data variables of ecological indicators that might be generalized, heavily weighted or considered negligible as determining factors in producing official designations and categories. Allowing seventh grade students to be conscious of the fact that classification systems or categories may be arbitrary, user-defined, and therefore, subject to change. Acknowledging this and challenging assumptions results in further hypothesis generation and question formulation leading to experimental design and the desire for an output of results to get at intriguing aspects of knowledge.

Eighth Grade Curriculum

Currently the eighth grade GIS curriculum is under development. The goal for the curriculum is to combine Earth system processes and human impacts into a combined GIS project. Due to the fact that students were exposed to GIS software in 6th and 7th grades, the students would be requested to design their own project, identify and secure their data sources, and produce an end product. Introducing a little bit more responsibility and challenge into the GIS curriculum is necessary for the eighth-graders to sustain their intellectual engagement and

activity. Students will be encouraged to work in teams because of the rigor of formulating hypotheses, determining independent and dependent variables and obtaining data for a GIS project, as well as the implicit advantages of the collaborative process to intellectual development. Collaborative teamwork is also important to consider because of computer infrastructure capabilities.

Once again, in an effort to position themselves in an ever-growing spatial context, the students would focus the project on a national or global scale. The curriculum would be situated in 8th grade science and draw upon erosion processes, climate change, or atmospheric processes. Examining human populations and their environmental impacts at these scales will require datasets that can be easily acquired through open source websites, such as ESRI, GIS data depot, or another data clearinghouse. A preliminary rubric will be created which the student will follow to guide them and to ensure that they will have enough time to develop their hypothesis, obtain the data, perform the analysis, and then develop a professional report which would incorporate policy suggestions for remediation.

Implementation Suggestions

Any educator or innovative instructor that has computer access can readily integrate ArcView into their grade-level curriculum. Accessing the ESRI website at (http://www.esri.com/getting_started/education/index.html) will provide initial information about how to download a free trial version of the software or contact support staff to assist with the procedure. For additional assistance, an educator might be interested in developing a beneficial collaborative linkage with their local University or Community College and contacting the academic department that specializes in teaching GIS. Frequently there are mutual needs that can be met, whether it is a faculty member or a graduate student interested in developing better GIS exercises or educators facilitating information among users.

Performance capabilities of school computers may sometimes be a concern among educators not familiar with ArcView GIS. We found that performance was best when exercises were prepared with previously tested datasets and that these were loaded onto each individual computer hard-drive. Using known datasets that were burned onto CD-ROMs ensured that all data layers were in the same projection and that the labs could be replicated in the future. Students followed "recipe-style" laboratory exercises and were instructed about where on their computer they could access the data. Walking through exercises with the class and then allowing them to mutually assist one another keeps students on task and engaged in the procedures. Rarely did we find students that weren't interested in the project or paying attention. We feel that this is partly because the students were using data that represented familiar locations or attributes of interest: also they were proud of and encouraged by their individual capabilities of manipulating and displaying the information.

Due to storage capabilities of district servers, a teacher must consider the fact that students are coming in and rebuilding their projects on a daily basis contingent upon a 50- or 90-minute class period. However, this is not necessarily a drawback. This repetition allows students to master the program. In today's world, students have grown up with high-speed multimedia interactions and GIS taps into this rapidly acquired capability by focusing on a visual computerized inquiry-based learning tool. Students in the middle school age brackets are interested in achieving visual results while being intellectually stimulated; GIS actively engages the

students in this endeavor. When they are working with data that is bolstered with preceding information derived from classroom activities or discussions they are quickly drawn into the material and able to pull out meanings or new insights.

As GIS continues to become integrated into new curricula, workshops and institutes will have courses available to teachers nationwide. We were fortunate, as a result of the UT at Austin NSF GK-12 program and the cross-disciplinary nature of the program that a majority of Covington Middle School teachers had access to GIS workshops. These were organized and carried out by the co-Principle Investigator, Dr. Barbara Parmenter, from the Department of Urban Planning and the NSF GK-12 graduate fellow, Veronica Chapa. These workshops taught teachers the basics and essentials about GIS: how to navigate the program, where to find data sources, how to manipulate data sets, and how to effectively ask questions and prepare layouts. Detailed information about this workshop can be found at the ESI GK-12 website http://www.esi.utexas.edu/gk12/workshops/gis.html along with tipsheets, tutorials, GIS data sources, and information on how to get further assistance. This quality instruction makes certain that teachers are being equipped with the most cutting-edge and accessible information available.

Conclusions

The age-level and educational sequence that takes place in middle school is ideal for combining the sophisticated and inquiry based technologies of GIS into the classroom (Fig.1). As students enter into 6th grade, they are entering a developmental phase of young adulthood, positioning themselves as intellectual individuals in a slightly broader community. In sixth grade they are introduced to the structure of scientific questions; hypotheses, variables, controls, data, and note taking or record-keeping. This is where the foundation of using geospatial technology is communicated and they learn how to manipulate and navigate the software. In seventh grade students are a bit more self-aware and begin to recognize how their inquiry skills can be stretched in an even broader context. It is at this point in the curriculum where students begin to think about the questions that they are asking in relation to the methods available to them via the GIS software capabilities. Entering into eighth grade, students are ready to take on the intellectual challenges and responsibilities of being young adults. It is at this juncture where students are thinking more abstractly and ready to explore possibilities and examine how their actions may fit into cumulative effects or impacts. It is in the eighth grade where students can use GIS to make predictions, model, and explore datasets. They become responsible for the experimental design of setting the project parameters, making decisions and assessing their progress and producing a compelling end-product.

Covington Middle School and the University of Texas at Austin NSF GK-12 program continue to develop GIS-based, interdisciplinary curriculum that aligns both within and across grade levels. This allows teachers to build upon previously taught concepts and provides a unique opportunity to integrate both science and social studies curricula while developing advanced thinking skills. Sixth grade students utilize GIS software to locate, analyze and map their local watershed. This is augmented in seventh grade when students further develop their knowledge of GIS by jumping scales to examine Texas ecological zones. These same maps are also used in Texas History, thereby bridging seventh grade science and social studies curricula. The GIS curriculum being developed for eighth grade will incorporate national or global environmental issues.

It is our goal to continue with the apt medium of ArcView GIS to educate science and social studies curriculum at Covington Middle School. Exposing students to the technologies that are available and proving that they are capable will create potential for future research questions. With the integration of ArcView GIS into middle school curriculum, students will have utilized the advanced skills of GIScience to examine biological and physical science and analyze human development and social patterns; thus, awakening a sense of place within their community, creating a sense of ownership, and developing a sense of stewardship.

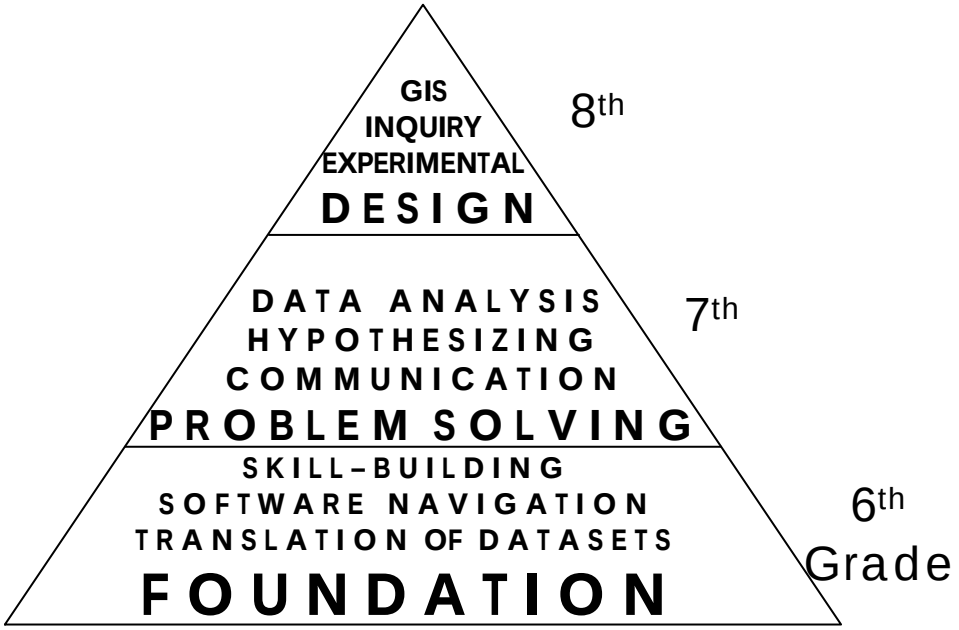

Figure 1: Mapprints to the future, GIS curriculum in Middle School.

Acknowledgements:

We would like to extend sincere gratitude and recognition to Dr. Jay Banner, Dr. Barbara Parmenter, Dennis Ruiz, Veronica Chapa, and Jessica Gordon who established the foundation for this project and facilitated the momentum every step of the way. Appreciation is also extended to the many other GK-12 Teacher-Fellow teams and individuals associated with the University of Texas at Austin NSF GK-12 program and the Environmental Science Institute. This project would not have been possible without the support of Principal Dr. Karen Rilling and cooperative science teachers at Covington Middle School. Lois Pierce was critical to building and maintaining the success of the interdisciplinary linkage between science and social studies. Leigh Lunsford, the Covington Computer Tech, patiently assisted with and maintaining all computers. The National Science Foundation GK-12 program provided initiative and financial support for this collaboration and will continue to reap the benefits as budding scientists, such as the Covington Middle School students, continue to advance science into the future.

References:

Chapa, V., Gordon, J., and Parmenter, B. 2004. *Creating Community: University of Texas at Austin and Local Schools*. ESRI EdUC Conference Paper #5095, San Diego, CA.

Author Information:

Jennifer K. Lipton, PhD Candidate
University of Texas at Austin NSF GK-12 Fellow
4205 Speedway, #305
Austin, TX 78751
512-471-5116
jenlipton@mail.utexas.edu

Nancy Poage Nixon
Covington Middle School
9105 N. Madrone Trail
Austin, TX 78737
512-288-3639
npoageni@austinisd.org

Connolly Coyle
Covington Middle School
3700 Convict Hill Rd.
Austin, TX 78749
512-923-4559
connollycoyle@hotmail.com