DOCUMENT RESUME

ED 407 264 SE 060 202

AUTHOR	McWilliams, Harold; Rooney, Paul
TITLE	Mapping Our City: Learning To Use Spatial Data in the Middle School Science Classroom.
INSTITUTION	TERC, Cambridge, MA.
SPONS AGENCY	National Science Foundation, Arlington, VA.
PUB DATE	Mar 97
NOTE	8p.; Paper presented at the Annual Meeting of the American Educational Research Association (Chicago, IL, March, 1997).
CONTRACT	ESI-94-52785
PUB TYPE	Reports - Descriptive (141)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	*Cartography; *Computer Uses in Education; Concept Formation; Educational Technology; *Environmental Education; Geography; Grade 6; Hands on Science; Interdisciplinary Approach; Intermediate Grades; Middle Schools; Problem Solving; Science Activities; Science Instruction; *Spatial Ability; *Student Projects
IDENTIFIERS	Boston Public Schools MA; National Science Foundation

ABSTRACT

Mapping Our City is a two-year project in which middle school teachers and students in Boston explore the uses of Geographic Information Systems (GIS) in project-based science, environmental education, and geography. The project is funded by the National Science Foundation and is being field tested in three Boston middle school science classrooms. This paper is a progress report on how those middle school students are creating and using spatial data to analyze an urban river. Questions explored relate to the ways that GIS can enhance student learning, which aspects of student learning and classroom practice are most affected by GIS, and the ways students use modified technology in the classroom. One participating school focused upon is an independent, high-achieving school for girls, where weekly classes were held with one group of 15 and one group of 30 sixth graders. Key findings address the use of maps to focus student attention on spatial aspects of the data, using GIS to help students discover relationships among spatial variables and to organize and store their data, making GIS technology easier to use, and having third-party data as a motivational tool. (DDR)

Mapping Our City:
Learning to Use Spatial Data in the Middle School Science Classroom

Paper presented at the annual meeting of the
American Educational Research Association
in the symposium

Tools for Learning:
How Technology both Masks and Illuminates Cognitive Dilemmas

Harold McWilliams
Paul Rooney
TERC
Cambridge MA 02140

Chicago, Illinois

March 1997

The research reported in this paper was conducted under the grant "Mapping Our City" (#ESI-94-52785) from the National Science Foundation.

Mapping Our City:
Learning to Use Spatial Data in the Middle School Science Classroom

This paper is a progress report on how middle school students are creating and using spatial data to analyze an urban river.

We are seeking answers to the following questions:

- How can GIS technology enhance student learning?
- What aspects of student learning and classroom practice does GIS affect most strongly?
- How do students use the modified technology in the classroom?

Overview of the Project

Mapping Our City is a two-year project in which middle school teachers and students in Boston explore the uses of Geographic Information Systems (GIS) in project-based science, environmental education, and geography. The project is funded by the National Science Foundation and developed by TERC. The purpose of the project is to explore how computer-based GIS systems, originally developed for use in industry and government, can enhance middle school science education, particularly in urban school systems.

A major part of our work has been to modify the interface of ArcView, a commercial GIS program developed by Environmental Systems Research Institute (ESRI) and to assemble a library of local data into an ArcView project we call *Explore Boston*. See Figure 1. Through using Avenue, the macro scripting language built into ArcView we have been able to make the interface simpler and more intuitive to use. In order to run efficiently, the software requires at least a 133 MHz Pentium computer. Because our schools did not have such powerful computers, we have placed one such computer in each school where we are working. We are currently field-testing the functionality of *Explore Boston* in three Boston middle school classrooms. This paper reports on our work in one of the schools.

The setting

The school is an independent, high-achieving school for girls. We are working with three classes of 6th grade girls, each consisting of about 15 students. We have been meeting weekly with the classes, first with one class of 15 and then with a second group of 30 composed of the other two classes. The teachers, who are experienced science specialists, participate in planning and conducting the 45-minute classes, but we have primary responsibility for setting the direction of the classroom work.

We are working with the students to study the water quality of the Muddy River, a highly polluted urban river that passes near their school. When we began working with them in January, they had already completed a semester's study of the river and were already familiar with many of the environmental issues affecting the river. The river originates in Jamaica Pond, a spring-fed lake, tumbles down a fairly steep grade for half a mile, passing through several small bodies of water before entering Leverett Pond. From there it meanders slowly, dropping barely ten feet in the remaining three miles, until it enters the Charles River. The Muddy River is a modified watercourse, having been designed in the 19th century by Frederick Law Olmsted, the famous landscape architect. It flows through Boston's Emerald Necklace parkway and forms part of the boundary between Boston and the Town of Brookline. See Figure 2.

The river has been the object of community concern for years and has been studied periodically by private engineering firms, academics, state agencies, and the U.S. Army Corps of Engineers. The teachers and their students have been involved with the river for several years and have established links with community groups advocating the rehabilitation of the river. Considerable controversy surrounds the river, and there is vociferous disagreement about how to restore it to its former condition. The students and teachers were quite well-informed about the issues when we began working with them and had already been collecting water quality samples from a site near their school. We hoped that GIS (in the form of *Explore Boston*) would allow them to explore spatial aspects of the river that had previously been unavailable to them.

In *Explore Boston* we provided basic local data, such as street networks, bodies of water, and land use information. We expected the students to add to the data base their own data about the river as well as data they might find from other sources. We sought to provide the framework and a "headstart" but to give them an opportunity to actively create spatial data relevant to their investigation of the river. As it turned out, the Army Corps of Engineers reports on the Muddy River proved to be an invaluable source of data. For several weeks the students were engaged in taking the data from the Corps' printed reports and entering it into *Explore Boston*. In doing so, they are significantly enlarging their understanding of the river.

One of our project goals was to involve the students in using their scientific knowledge and their GIS tools for a community project. As it turns out, they have been invited by one of the Muddy River advocacy groups to make a presentation to the group's annual meeting in May. The students will use the GIS technology and the data they have assembled to make their presentation at the public meeting. An important part of the students' motivation to master the GIS technology lies in this imminent practical application of their work.

Key findings so far

The project still has several months of classroom work remaining, but what, at this point in the project, have we learned?

- Using maps focuses student attention on spatial aspects of the data.

  This may be obvious, but it is worth stating. When we started working with the students they had already been studying the river for a semester. Yet their awareness of the river as a spatial entity was rudimentary. In one of the early classroom sessions we provided a black and white paper map showing the Muddy River in outline and asked them to locate the river and shade it blue with colored pencils. Surprising to us, this was not an easy task. The students did not have a clear idea of the river's geography and needed some time to actually locate it on the map. They also were somewhat unclear about the location of their school and the sampling site from which they had drawn river water for analysis.

- Using the GIS helps students discover relationships among spatial variables.

  Initially, the students were familiar with many of the problems of the river, such as:

  - overgrowth of phragmites
  - low levels of dissolved oxygen (DO) and eutrophication
  - leaking underground storage tanks (LUSTs)
  - combined sewer overflows (CSOs)
  - illegal cross-connections between sewers and storm drains
  - contamination with fecal coliform bacteria

  However, these issues were, for the most part, viewed separately and "a-spatially," as if they applied equally to the entire 3.5 miles of the river. The students were aware in a general way that phragmites grew only in certain parts of the river and that the leaking underground storage tanks and CSOs were located "somewhere," but their notions of "where" were quite vague. As they began to work with the GIS, these notions were dramatically refined.

  They had collected water quality data (such as DO levels) from a sampling spot near their school, and they tended to generalize from the results at this location to the entire river. They somewhat naively or without reflection assumed that the entire river was similar to the spot they had sampled. Once they looked at the additional data gathered by third-parties (such as the Corps of Engineers), they realized this was not true. They learned that DO levels in the upper reaches of the river were generally quite good (above 6.0 ppm), whereas levels in the lower reaches of the river (the area they had sampled) were fairly poor. See Figure 3.

In trying to explain the dramatic change from the DO levels in the upper reaches of the river, the students noticed that intervening spatially just above the first drop in DO was a stormwater drain (Tannery Brook Drain) that was suspected of having illegal sewer connections. This was clear circumstantial evidence that the drain was, indeed, contributing to the drop in DO level. See Figure 4.

- The GIS helps students organize and store their data.

Simple as this sounds, it is not the trivial matter it might seem to be. Teachers and students work in very cluttered environments, and simply keeping track of data is difficult. Many teachers have said to us that they hope the computer will help students keep track of their data. Professional scientists use computerized data bases and sophisticated display technologies to organize and display the large amounts of data that must be dealt with in complex investigations, and, as Seymour Papert wrote years ago, tools that professionals use are also, with modifications, good tools for students.

- Making the GIS technology simpler to use encourages open-ended exploration of the data.

One of the challenges with having lots of data is getting flexible access to it and being able to explore it in creative ways. For an expert, the native ArcView interface allows easy and flexible access to the data. But, just like learning to play the piano, it takes time and practice to acquire the skill. In *Explore Boston* we have modified the native ArcView interface to facilitate easy exploration of the data by the less experienced user. By providing access to the data through pull-down menus rather than through the folder and file directory structure, we have made it easier to get at the data you want. And, through button-activated Avenue scripts (macros), we have automated many of the most frequently used functions.

ArcView lets you query data points on the screen map. By clicking on a point with the "identify tool" you access the attribute data about that point. For example, clicking on a point in a "dissolved oxygen" theme may bring up information on the precise DO level, the date and time of sampling, the name of the person who drew the sample, and the exact location of the sampling site. See Figure 5.

- The GIS technology helps students manage complexity.

  We observed in the classroom that when students recorded data on paper maps showing the river system, the drains, the sampling sites, the stands of phragmites, and the data obtained at the sampling sites, the maps quickly became so cluttered and "busy" as to be almost unusable. See Figure 6. The GIS technology, on the other hand, made it possible to control the amount of data displayed on the map at any one time. Students can choose to add only the layers of information they need at the moment. The "layers" metaphor makes sense to students and does not seem to pose conceptual difficulties. By controlling the data displayed at any given time, students can manage complex datasets in ways that promote clearer understanding.

- Having third-party data makes student data more useful and interesting.

  In this study, we have found third-party data to be very useful. Combining student data with third-party data creates a win-win situation. The student data is, in a sense, "extended" by the addition of the professional data. Conversely, the third-party, professional data is "personalized" by the fact that students have collected similar, if not identical, data themselves. Students can more easily engage with the professional data because they, too, have collected data and experienced the difficulties. Moreover, through using professionally-collected data, the students are able to see their data in the context of a larger scientific study.

- Multimedia increases student engagement with GIS technology.

  ArcView facilitates the use of maps, tables, and charts, and allows the user to link digital images, such as photos and scanned images to specific geographic locations. Students find this feature very engaging. As part of their earlier study of the river, one of the teachers had taken a set of 35 mm slides depicting various aspects of the river. We converted the photographs to digital format and stored them in the project files on the computer. The students then linked them to specific spots on the digital map and composed text to describe their significance. The photos and their descriptions are then displayed on screen when one clicks the mouse on a point on the map. See Figure 7. The students plan to take additional photos of the river conditions later in the spring and link them to their growing database of information.

- Data creation takes time, but students don't mind.

  In order to reap all the benefits of using GIS technology, we felt that students should participate fully in the data creation process. However, creating data in a GIS is time-consuming. Once students have learned how to create new themes and enter data it frankly takes a lot of time to enter the data. Fortunately and interestingly, students do not complain about data entry. At this point, at least, it seems their motivation for the task more than makes up for its repetitiveness.

- GIS technology helps sensitize students to issues of data quality.

  In general, schools do not encourage students to think much about the quality of the data they use. Often the data that students work with comes from textbooks and carries little or no information about its "quality." It is presented out of context and without "metadata." But, as every working scientist knows, the quality of the data strongly influences the quality of the results. In the famous phrase: "garbage in, garbage out." Recently, in programs where students are involved in serious data collection there is greater concern that students become more intelligent and critical users of data. (For one prominent example, see The GLOBE Program.) Through working with *Explore Boston* the students are becoming more aware of the importance of metadata. They are learning, for example, that data has a "when, a where, a who, a what, and a how," and that all of these must be recorded in order to document the data.

- Teachers and classrooms need "behind-the-scenes" technical support in order to use GIS technology effectively.

  In order to make the technology easily accessible, it is necessary to have a skilled technician working behind the scenes. In our project, a GIS specialist has provided continuing support. In the future, in order to access local datasets and provide appropriate modifications to the data interface, it will continue to be necessary to have the ongoing assistance of a GIS specialist. It is possible, however, that this assistance and support can be provided by high school and postsecondary students trained in GIS.

Conclusions

We are encouraged by our findings so far. Our hope that GIS technology would open up new areas of understanding in student science investigations is being borne out. The students are actively engaging in the process of data creation and analysis. They are making decisions about how to display their data and are planning for a public presentation of their results. Most importantly, they are effectively using the new technology with spatial data to discover aspects of the river system of which they had previously been unaware.

AREA 1997

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement (OERI)
Educational Resources Information Center (ERIC)

SE060302

ERIC

REPRODUCTION RELEASE

(Specific Document)

I. DOCUMENT IDENTIFICATION:

Title: Mapping Our City: Learning to use Spatial Data in the Middle School Science Classroom	
Author(s): Harold McWilliams Paul Rooney	
Corporate Source: TERC	Publication Date: March 1997

II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, *Resources in Education* (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic/optical media, and sold through the ERIC Document Reproduction Service (EDRS) or other ERIC vendors. Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce the identified document, please CHECK ONE of the following options and sign the release below.

[X] Sample sticker to be affixed to document

Check here
Permitting microfiche (4"x 6" film), paper copy, electronic, and optical media reproduction

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
Sample
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

Level 1

Sample sticker to be affixed to document [ ]

or here
Permitting reproduction in other than paper copy.

"PERMISSION TO REPRODUCE THIS MATERIAL IN OTHER THAN PAPER COPY HAS BEEN GRANTED BY
Sample
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

Level 2

Sign Here, Please

Documents will be processed as indicated provided reproduction quality permits. If permission to reproduce is granted, but neither box is checked, documents will be processed at Level 1.

"I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce this document as indicated above. Reproduction from the ERIC microfiche or electronic/optical media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries."

Signature: Harold McWilliams, Paul E. Rooney	Position: Project Director
Printed Name: Harold McWilliams, Paul Rooney	Organization: TERC
Address: 2067 Massachusetts Ave, Cambridge MA 02140	Telephone Number: (617) 547-0430
	Date: April 10, 1997

OVER

CUA

THE CATHOLIC UNIVERSITY OF AMERICA
Department of Education, O'Boyle Hall
Washington, DC 20064
202 319-5120

February 21, 1997

Dear AERA Presenter,

Congratulations on being a presenter at AERA[1]. The ERIC Clearinghouse on Assessment and Evaluation invites you to contribute to the ERIC database by providing us with a printed copy of your presentation.

Abstracts of papers accepted by ERIC appear in *Resources in Education (RIE)* and are announced to over 5,000 organizations. The inclusion of your work makes it readily available to other researchers, provides a permanent archive, and enhances the quality of *RIE*. Abstracts of your contribution will be accessible through the printed and electronic versions of *RIE*. The paper will be available through the microfiche collections that are housed at libraries around the world and through the ERIC Document Reproduction Service.

We are gathering all the papers from the AERA Conference. We will route your paper to the appropriate clearinghouse. You will be notified if your paper meets ERIC's criteria for inclusion in *RIE*: contribution to education, timeliness, relevance, methodology, effectiveness of presentation, and reproduction quality. You can track our processing of your paper at http://ericae2.educ.cua.edu.

Please sign the Reproduction Release Form on the back of this letter and include it with **two** copies of your paper. The Release Form gives ERIC permission to make and distribute copies of your paper. It does not preclude you from publishing your work. You can drop off the copies of your paper and Reproduction Release Form at the **ERIC booth (523)** or mail to our attention at the address below. Please feel free to copy the form for future or additional submissions.

Mail to:

AERA 1997/ERIC Acquisitions
The Catholic University of America
O'Boyle Hall, Room 210
Washington, DC 20064

This year ERIC/AE is making a **Searchable Conference Program** available on the AERA web page (http://aera.net). Check it out!

Sincerely,

Lawrence M. Rudner, Ph.D.
Director, ERIC/AE

---

[1]If you are an AERA chair or discussant, please save this form for future use.

ERIC® Clearinghouse on Assessment and Evaluation