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Introducing Geographic Information Systems to General Math students.

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Introduction

In 2005, I gave a talk entitled *A Picture is Worth a Thousand Words*; the purpose of the talk was to present ideas regarding a series of web-based tutorials. These tutorials would emphasize information literacy skills and encourage students to incorporate graphs, charts; and Geographic Information Systems (GIS) concepts, especially maps into their research assignments.

One result of the talk was the beginning of collaboration with Professor Vrunda Prabhu, a Bronx Community College mathematics professor. Professor Prabhu noted in our preliminary discussions that some students experienced math anxiety due to previous unsuccessful exposures to instruction. She expressed hope that GIS exposure would motivate student interest in the underlying mathematics that created the maps. Studies have shown that students' who participate in GIS activities, engage higher-level thinking skills, and project a greater sense of positive self-efficacy (West (2003); Baker and White (2003)).

The tutorials were designed to accomplish three goals: the creation of a situated problem-based environment where students could immerse themselves in authentic problems; the introduction to basic Geographic Information Systems concepts and spatial analysis skills; and the promotion of student self-efficacy skills.

GIS knowledge is a 21st century skill that fosters workforce abilities, citizenship, and community participation. Although, GIS applications are typically associated with physical and social science domains; some innovative researchers are beginning to use GIS as a means of introducing practical data analysis concepts. Enyedy and

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Mukhopadhyay (2007) used GIS in a situated social justice context to help urban students realize how mathematics is relevant to their lives and their communities. Students used GIS to identify places and create demographic profiles of the surrounding neighborhood. In the creation of maps, a variety data analyzing methods were employed including calculations of central tendency, measures of spread, and methods to analyze bivariate data and correlations. Students then asserted claims regarding their neighborhoods based on the resultant maps and data analysis. Although, no actual statistics were formally taught, students learnt concepts based on instruction prompted by their questions or through reflective discussions and debates about their assertions. One of the conclusions of this study was that GIS made the mathematics relevant to the students because they were familiar with the places being mathematized. Furner and Ramirez (1999) advocated the use of GIS as a means of discovering mathematics through the social sciences, in the context of analyzing maps and graphs related to specific occurrences. For example, students may learn about statistics by evaluating the population distribution of a state; noting the population density of urban vs. rural regions.

What is GIS?

Geographic Information Systems (GIS) are software applications that visually explore spatial data relationships. *Spatial data* is information to which a geographic coordinate system such as longitude and latitude can be applied. GIS applications provide sophisticated analysis such as identifying patterns and clusters; but are also used for simpler analysis such as mapping the most and least, mapping density, and mapping change.

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The outputs of these analyses are thematic maps that comprise a minimum of two layers: a geographic base map and the thematic data. The geographic base map may contain a specific point, a series of points comprising a line, or a series of coordinate values representing a polygon. Data is frequently represented as categories, counts, amounts, ranks or ratios, and is displayed on transparent layers. Layer data is represented in the form of: a choropleth, where color shading is used to represent various categories or range of data; a dot density, where one dot represents a specific count of the variable; and a proportional symbol where the symbol varies in size relative to the value of the variable.

Background for the project.

In my 2005 talk, I proposed creating a series of tutorials. The situated setting for the tutorials would be the vacant Kingsbridge Armory located approximately one mile from the Bronx Community campus. The armory built in the early 1900s was once considered the largest in the world. By the mid-1950s, the armory's role had been reduced to hosting tradeshows, quarter-car racing, and local fairs. Most recently, a portion of the site housed a homeless shelter. Over the past decade a community organization the Kingsbridge Armory Restoration Association (KARA), and the city and county governments have failed to agree on the best use of the facility. A current proposal favors a combination retail mall and entertainment complex.

The armory and the community college reside in Bronx County, which has the distinction of being the poorest urban county in the nation. According to the 2002 American Community Survey, 52% of county residents identify as Hispanics, 36% identify as

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African Americans; 28% of all families and 42% of female-headed households earn below the poverty level; and nearly 4 out of 10 (37%) residents age 25+ have not earned a high school diploma.

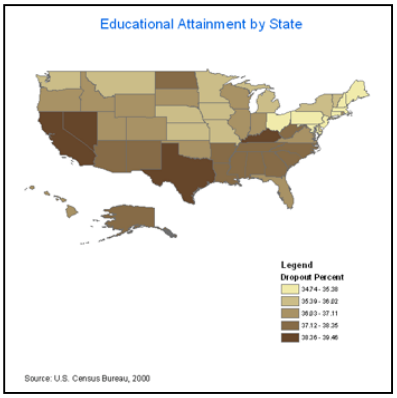
In the situated environment, student groups assumed the role of consultants to KARA and are required to research and create a series of documents that address issues regarding appropriate land use; they must also construct a demographic profile of the community that incorporates appropriate graphs, charts, and thematic maps.

Potential activities include: developing a basic demographic profile of the community, that include factors such as ethnicity, income, education levels, and family size; exploring the relationship between educational attainment and income; determining which industry sectors employ the most residents; and assessing the over crowdedness of schools.

Professor Prabhu and I have developed a true collaboration. Each semester, she has invited me to present a GIS overview and conduct a mini workshop for one of her classes. These workshops have provided a sense of which exercises work and the level of student interest.

Students Projects

For my first student collaboration, I was asked to assist student groups who were interested in creating thematic maps for their final project. In one class, a group of five students expressed interest in creating a series of maps that contrasted the Dropout rate (educational attainment)



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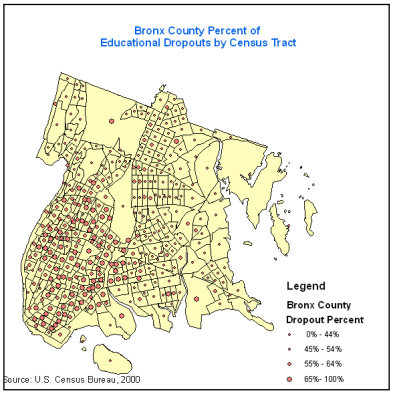
with income. Over the course of a week, I met with the students three times and we created four maps: individual U.S. and New York State maps indicating levels of educational attainment, grouped by state and county respectively; and New York City and Bronx County maps indicating both educational attainment and income, grouped by census track.

The maps formed the basis of the students' power point presentation and provided a strong visual sense of educational literacy rates. The maps revealed patterns that were not initially realized. Such as in the U.S., literacy rates were highest in the Northeast and lowest in the states bordering Mexico, which led to further questions regarding the contribution of Mexican migration to the literacy rates of the Border States. Another surprising revelation was the less than 40% high school completion rate for some South Bronx census tracks.



Whereas this project was beneficial to the students, it wasn't an efficient use of time. We simply attempted to accomplish too much. In the sessions, I guided students through the process of locating, downloading, editing, and importing Census data into the GIS application; and created the maps according to their specifications. By the end of the workshops, the students had gained an appreciation for GIS capabilities; but were unable to recreate thematic maps themselves. This experience resulted in a rethinking of the types of activities to be designed for future projects.

For my second student activity, I created an exercise that enabled students to conduct a

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simplified analysis of Bronx County school districts. The assignment was designed for a Math 01 basic skills course and situated in the following context. Students were asked to recommend which district(s) should receive additional funding. The assignment provided students a table of basic statistics including each districts' seating capacity, actual number of enrollments, # of elementary schools, and a nominal district rating ranging from A-F. The students were required to calculate a number of basic statistics such as the percentage of elementary school age students within each district, percent of over crowdedness, and then rank of the districts according to one or more of provided and/or calculated variables. The students were also required to write a short paragraph indicating which district(s) were in greatest need for additional funding, and to create a choropleth map indicating the districts' relative rankings. Optionally, students were encouraged to create pie charts or bar graphs of the data.

The data provided the students were a combination of actual data obtained from the Department of Education's web site and adjusted values that varied some of the percent calculations. This exercise seemed particularly effective for the students. They arrived at the same calculations, but in some cases different conclusions. As I understand in one of the classes, a group of students independently created as their final project a Bronx County poster illustrating data that was researched on their own.

As a Systems Librarian, one of my responsibilities is to help students improve *Information literacy* skills; which is the ability to recognize an information need, retrieve the desired information, and communicate the findings effectively. I believe the thematic map making capabilities of GIS applications allow users to interpret and visually portray

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interrelationships among related data. I also believe that the open-ended nature of GIS problems provide students the opportunity to work collaboratively, engage higher-order thinking skills, and develop practical quantitative skills.

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