

Spatial Thinking with ArcExplorer--Java Edition for Education: Applications for Grades 4-6

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Abstract

The newly released ArcExplorer--Java Edition for Education offers new opportunities to introduce younger students to using GIS to improve spatial thinking. The simple interface and limited command set make it ideal for both younger students and their teachers. We've developed a suite of activities using ArcExplorer--Java Edition for Education to teach students in grades 4-6 about latitude and longitude, spatial proximity, querying and other key spatial skills. These activities connect directly with curriculum standards in these grades in both science and social studies. We'll demonstrate these activities and relate our observations of classrooms using them, along with teachers' reflections on that use. We'll conclude the session with a discussion of future plans for developing additional activities.

Introduction

While GIS is a very attractive tool for K-12 classrooms, relatively few teachers and students are actually using it on a regular basis (Kerski, 2003). There are a variety of reasons for this lack of use, but one is that there is not a clear entry point and activities available for younger students. While students can certainly use ArcView 3.x, teachers can find it intimidating and the available activities (e.g. **Mapping Our World**) are more appropriate for older students. However, with the release of ArcExplorer – Java Edition for Education (AEJEE), there are new possibilities for younger students and their teachers.

While the ultimate goal would be a scope and sequence for the effective use of GIS across the K-12 continuum, we have begun by developing a set of introductory activities for AEJEE that address curriculum content and standards for grades 4-6. In this paper, we will describe the activities and share initial reactions from students and teachers.

Why GIS for Elementary Students?

The elementary curriculum is already beyond overflowing with content needed to meet state standards and the No Child Left Behind rules. Why add one more thing? The short answer is very simple. Many, if not most, of our current students are visual learners and can take advantage of the technology to help them learn core content. GIS allows teachers to integrate technology directly into a variety of content areas, including social studies, science, and/or math, allows students to use technology as a tool to help understand their world. Finally, GIS is foremost a tool to make decisions. That is, GIS users are trying to solve a problem of interest and they use the software to allow them to make a decision or come to a solution. Students can do the same thing and have the experience of making a decision in the context of a problem. This takes the students beyond simple fact absorption and helps them to build critical-thinking skills, an evermore important requirement of our knowledge-based economy.

GIS Activities

We've developed four lessons for students in grades 4-6 to introduce them to GIS and making decisions using data. The activities are sequenced as follows:

Imaginary Lines - Students explore latitude and longitude and the locations of different countries with respect to the hemispheres of the Earth.

Where Are You - Students map their location on the Earth with respect to their country, county and ecosystem.

Current Quakes - Students download current earthquake data from the Internet and look for patterns in seismic activity across the globe.

Maps for Decision Making - Students build a base map of a small town and determine where an additional fire station should be located. Students also decide which roads

should be closed to facilitate the visit of the President of the U.S. to a local university. Before we explore each of the activities, we need to discuss the AEJEE software.

GIS Software

There are many GIS packages available. However most of them are intended for audiences other than elementary students. The activities described above were written for Arc Explorer – Java Edition for Education. This is a Java-based package that runs on various versions of Windows and the Macintosh OS X operating system. It is freeware and available for download at <http://www.esri.com/aejee>. When you download the software, you also get wide variety of interesting data to explore. With this software, you can even access ArcIMS data directly from the Internet and put it on a map with a couple of clicks. We've helped teachers in a variety of schools install and use the software with positive results and few problems.

AEJEE can perform the basic functions of a GIS, such as displaying and symbolizing data layers, querying, and buffering. It does not allow the full range of control of the map symbols, layout, or data editing as ArcGIS 9 or ArcView 3.x. However, many of these functions are not needed in introductory activities. The limited range of tools make the software more accessible to younger students, and especially their teachers.

Activity Descriptions

Each activity relates to standard topics in grades 4-6 and introduces basic functions of GIS software. The relevant national curriculum standards addressed by each activity are listed in Appendix A. Every activity comes with four parts: instructions for the activity, a student worksheet, teacher notes, and the data for the activity. The teacher notes contain learning goals/objectives, connections to standards in different content areas, and sample answers to the student questions. Every document is in Microsoft Word format, making it easy to customize the activity to a particular classroom or subject. We'll explore each activity in turn and show sample screenshots to illustrate the activity.

These activities (and others) can be downloaded at no charge through the ArcLessons site sponsored by ESRI, Inc. Go to <http://www.esri.com/arcllessons> and select ArcExplorer in the "Search by Software" menu.

The activities are listed in the order we suggest that you do them. Each activity builds on the previous one, moving from introductory-level GIS skills to more advanced skills and thinking by the time you've completed the final activity. The directions also vary from very prescriptive in the first lesson to somewhat open-ended in the final lesson.

Imaginary Lines

In this activity, students focus on the basics of latitude and longitude. It is a great first activity as it presumes no prior knowledge of GIS. The students start by exploring the function of different tools as they explore a map of the world. One by one, they add

layers with different data, including lines of latitude and longitude. They identify the position of the Equator and Prime Meridian and explore how latitude and longitude vary as you move around the globe. Figure 4 shows a screenshot showing a map with some of the layers the students will explore.

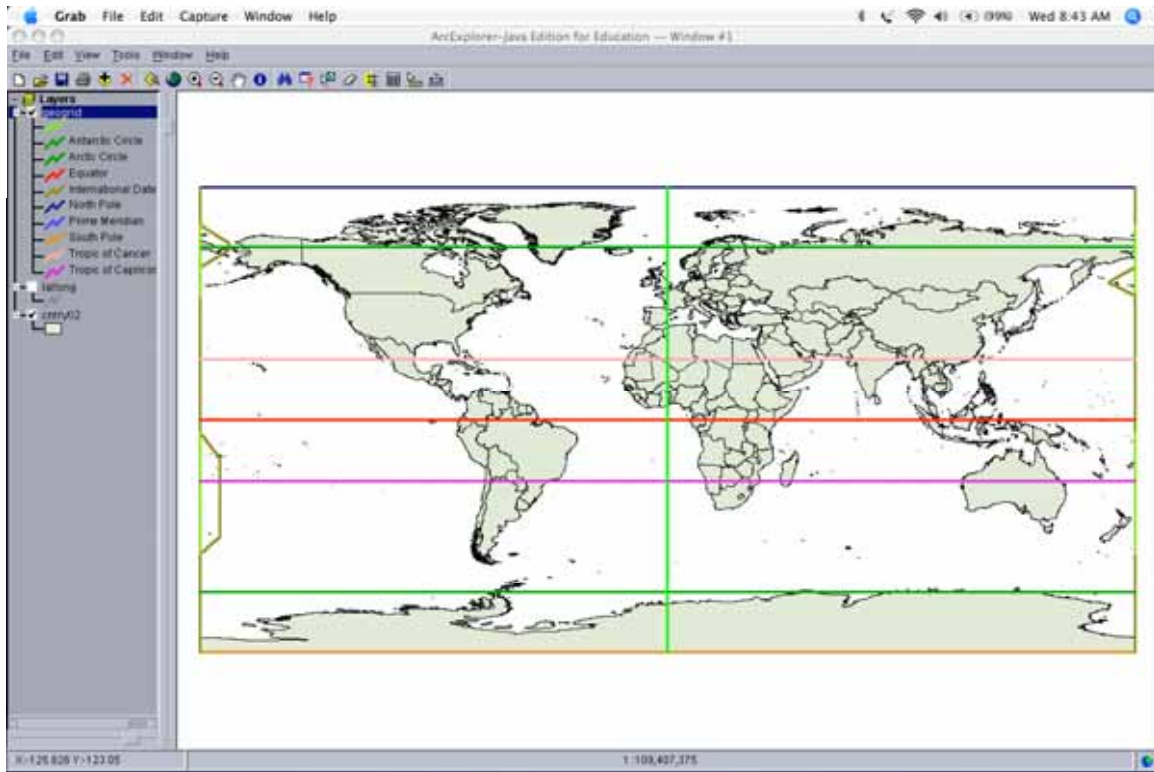


Figure 4. Screenshot of Imaginary Lines. In this portion of the activity, students are exploring how latitude and longitude vary across the globe. Note that the latitude and longitude are shown in the bottom left-hand corner and the scale of the map is shown at the bottom center of the screen.

For older students, there is a data layer that contains important latitude and longitude, including the Equator, Prime Meridian, Tropics of Cancer and Capricorn, International Dateline, along with the Arctic and Antarctic Circle. For younger students, this can be replaced with a data layer that only contains the Equator and the Prime Meridian. We've found that for younger students, the simpler layer makes it easier for them to understand the activity.

As students continue with the activity, they explore the differences between the different hemispheres (northern and southern, eastern and western). Students learn how to do simple queries to identify world capitals that are in different hemispheres. Queries are questions that the ArcExplorer software can answer with the available data. Figure 5 shows a query identifying all the cities in the data layer (only a subset of world capitals are included in the data layer) that are both in the northern and western hemisphere. The query window is also shown to illustrate how the students build their questions. This is a wonderful connection with databases and with some basic mathematical reasoning (the

logical "and" and "or").

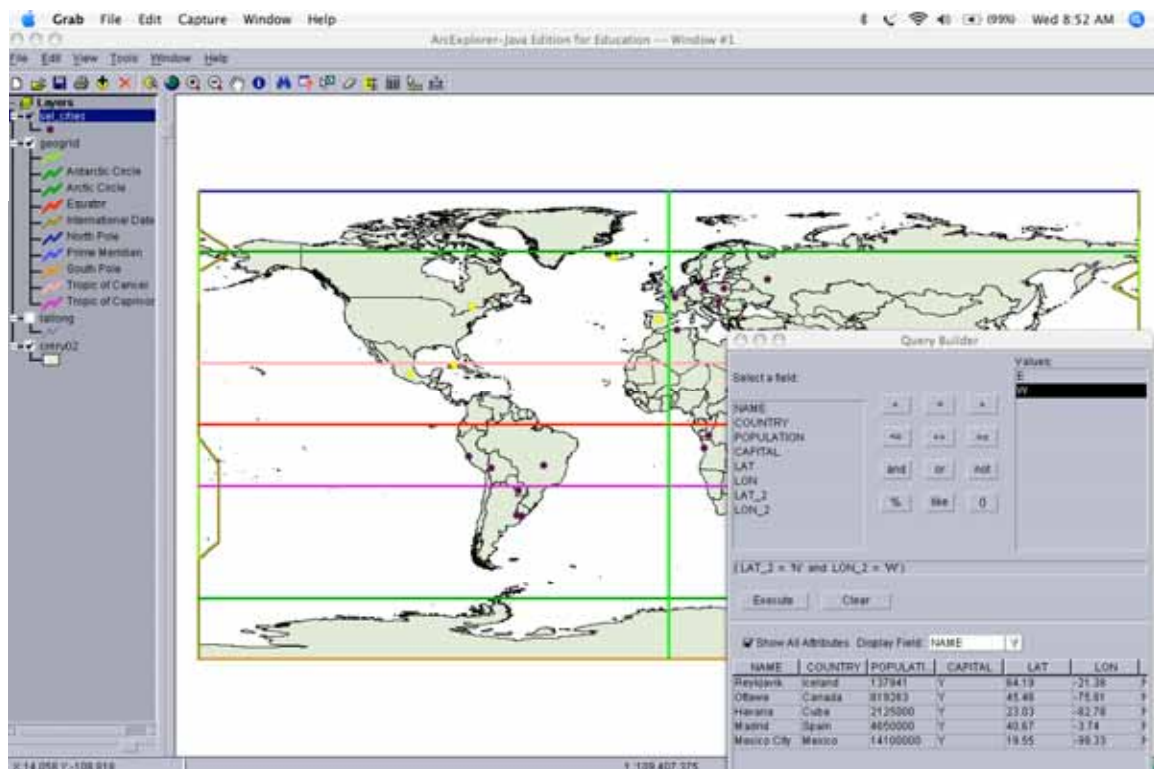


Figure 5. Screenshot from Imaginary Lines. Students build simple queries to identify which cities are in the different hemispheres. They can also build compound queries to locate cities in, for instance, both the northern and western hemispheres. Selected cities are highlighted in yellow.

Imaginary Lines has both strong geography and strong mathematics content and has many possible extensions using the data the comes with the activity or with the downloaded software.

At the end of the activity, students explore how the scale of a map varies based on the features which you're exploring (continents vs. counties).

Where Are You

In Where Are You, students build a base map of a community in the United States by adding the latitude and longitude of the community from a text file. This is the same process that students would use to upload data from a Global Positioning System (GPS) unit. GPS units allow students to record the latitude and longitude of their location and are great tools for students to use to collect data about their localities. A detailed discussion of GPS in Education is beyond the scope of this paper, but you can find out more at <http://www.nasm.si.edu/exhibitions/gps/>.

After students have uploaded the location and put it on the map, they add additional data

layers and identify to which state, county and ecosystem the community belongs. Figure 6 shows a screenshot with the various data layers.

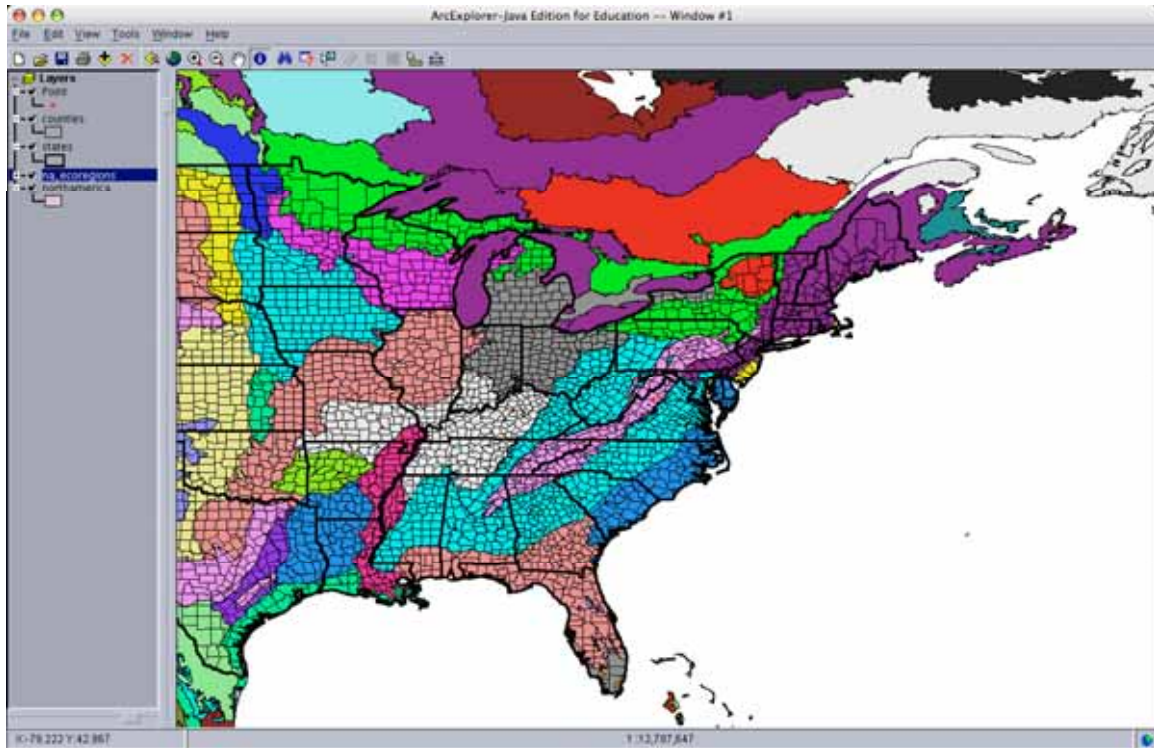


Figure 6. Screenshot from Where Are You. Students identify state, county and ecosystem using the information tool. The sample community is Harrisonburg, VA, marked as a red dot in the central Shenandoah Valley. Students can easily customize this activity to their own location by knowing the relevant latitude and longitude.

Once students have built their base map, they explore the idea of a geospatial buffer. In the context of GIS, a buffer is simply a way to locate all the features on a map that are within a certain distance of your location. A cookie cutter is a good analogy to a buffer. In the activity, students identify what rivers and cities are within ten, thirty or fifty miles of the sample community. Figure 7 shows sample output from this process.

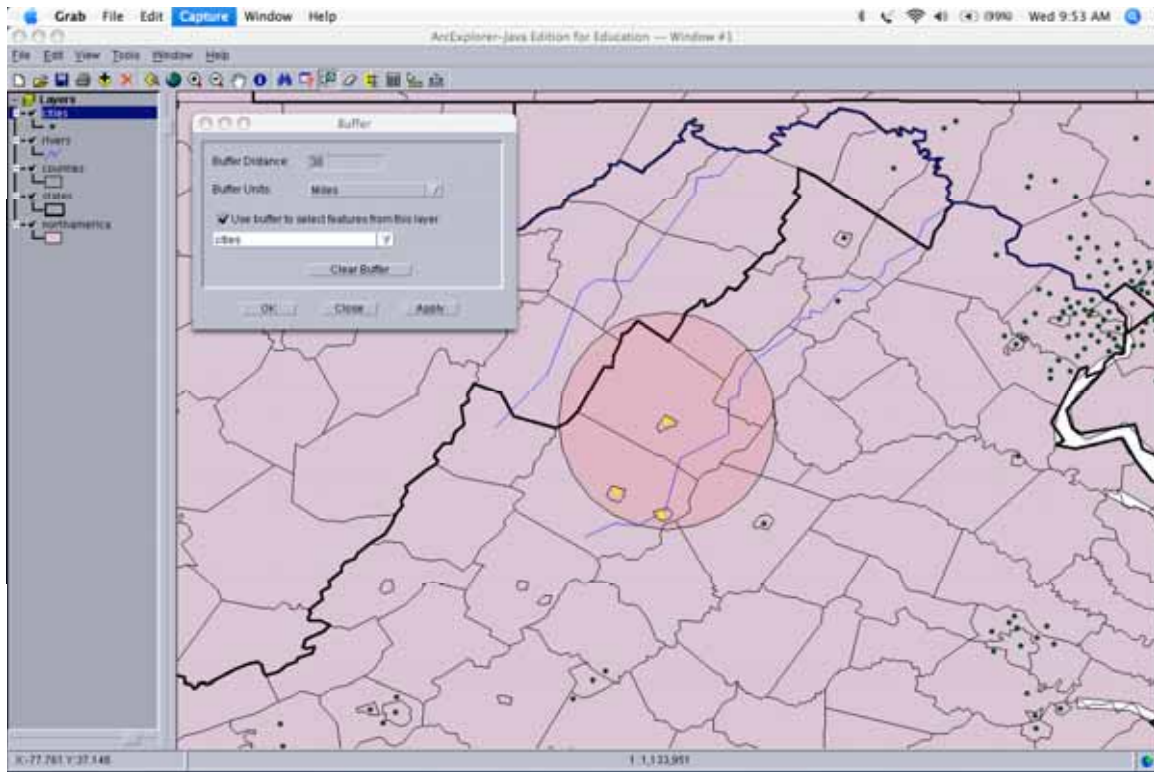


Figure 7. Screenshot from Where Are You. This map shows a 30 mile buffer around Harrisonburg, VA. The cities that are highlighted in yellow are within the layer. Buffers are a very powerful tool for understanding spatial relationships.

Current Quakes

In Current Quakes, students download current earthquake data from the Internet and add it to a map, using the same technique as in Where Are You. They then classify display the quakes in different ways and use buffers to determine what cities are at risk from these natural hazards. The website where they download the earthquake data (National Earthquake Information Center – <http://neic.usgs.gov>) includes quakes from the prior seven days, which often includes events taking place within hours of class time. The currency of the data is very attractive to students. Figure 8 shows a sample screenshot of the uploaded current quakes.

In the latter part of the activity, students identify the quake with the largest magnitude of the most recent quakes and create a buffer to see which countries would be most affected. As we're writing this paper, the largest quake was in almost the same spot as the large quake that created the "killer" tsunami in late 2004. Figure 9 shows a 200 mile buffer around the epicenter of this quake.

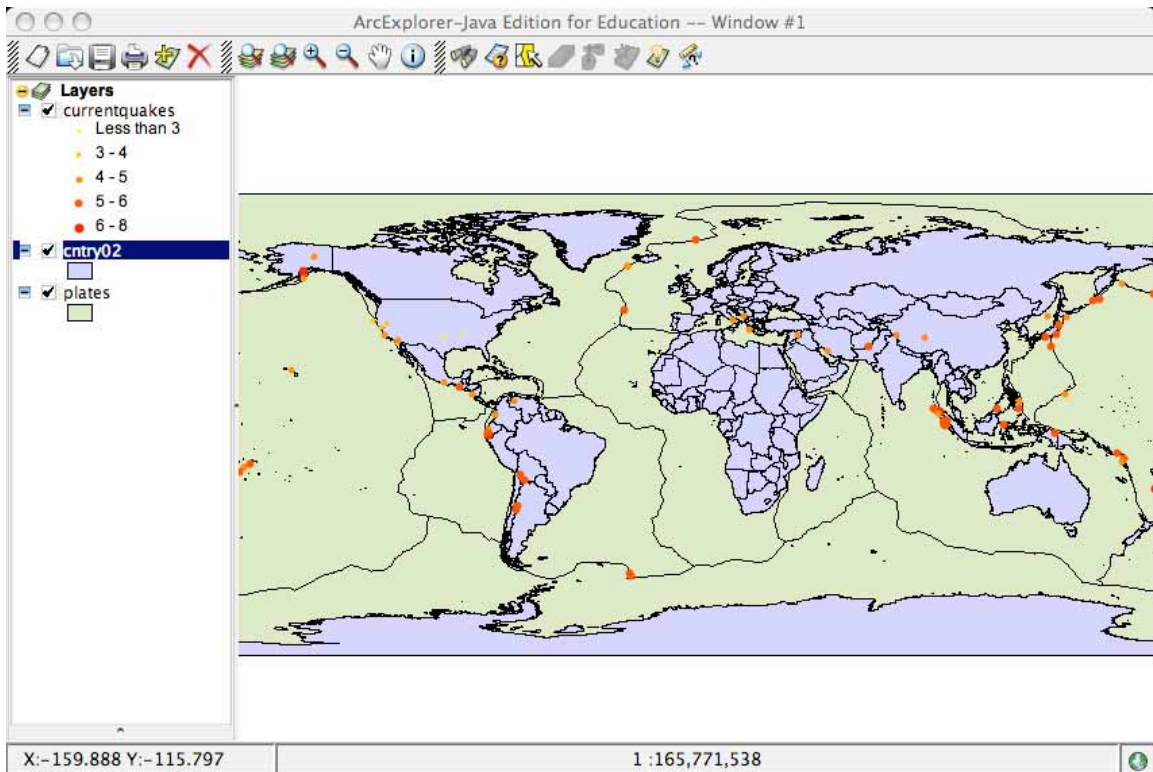


Figure 8. Screenshot from Current Quakes. In the first part of the activity, students download and map the current quakes. The varying colors and sizes of the dots on the map represent the magnitudes of the quakes. The map also shows the tectonic plates that comprise the Earth's surface. Students analyze the map and look for patterns. The data that comes with the activity includes a data layer with world volcanoes and a data layer with a full year of earthquakes.

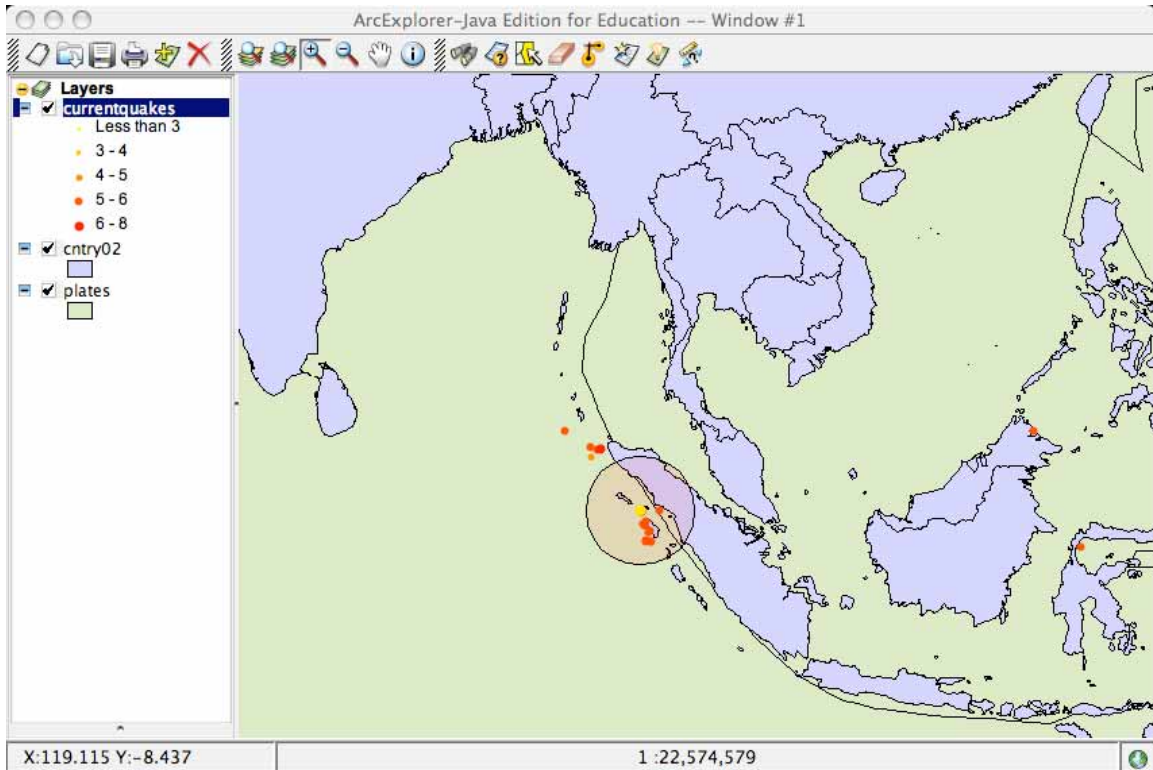


Figure 9. Screenshot from Current Quakes. The largest quake during the most recent week (27 May 2005) was located near the Nias region of Indonesia and had a magnitude of 6.9. The circle on the map represents a buffer of 200 miles.

Maps for Decision Making

Maps for Decision Making represents the culminating activity in this sequence and combines the skills learned in the other three activities. Students explore the details of a small town and determine where an additional fire station should be placed by using buffers around the current fire stations. Figure 10 shows a screenshot of this analysis.

Students also explore which roads should be closed to facilitate a visit of the President of the U.S. to a local university. Figure 11 shows just how much of the city would need to be shut down to close all roads within 2 miles of the campus.

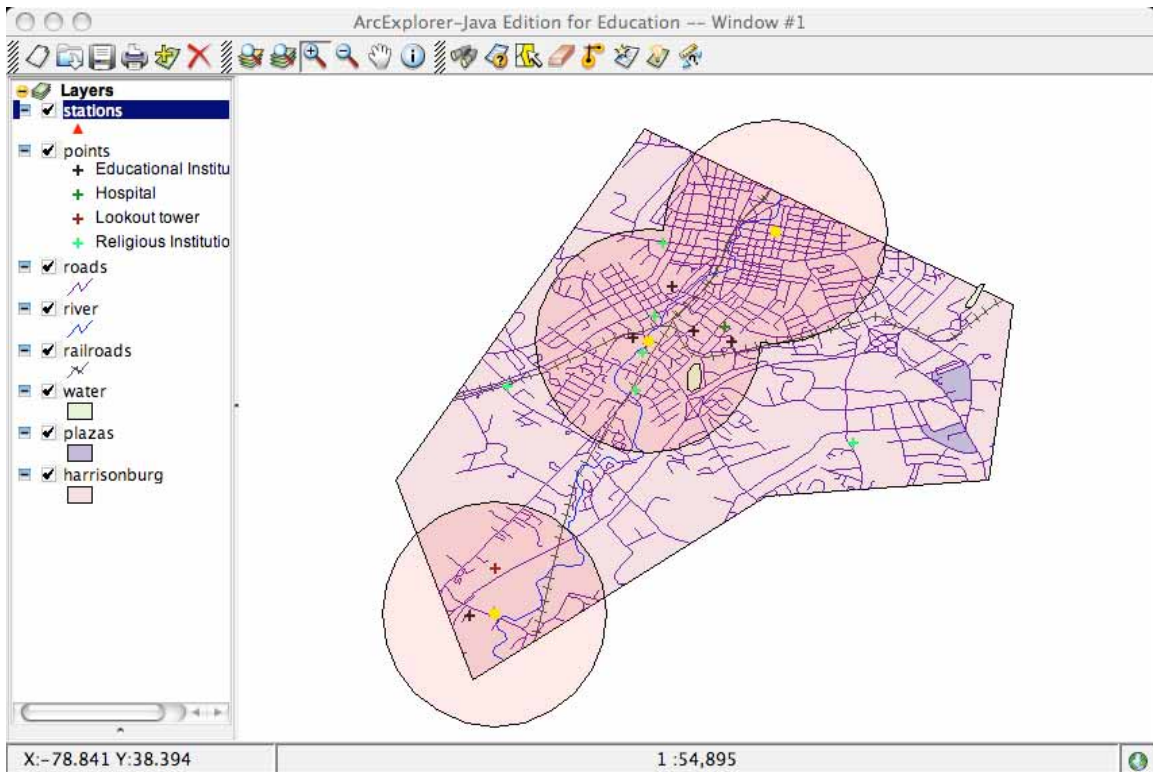


Figure 10. Screenshot from Maps for Decision Making. Students identify the fire stations in a small city and create 1 mile buffers (shown as circles). Students then decide where to put a fourth station to better protect the citizens and buildings.

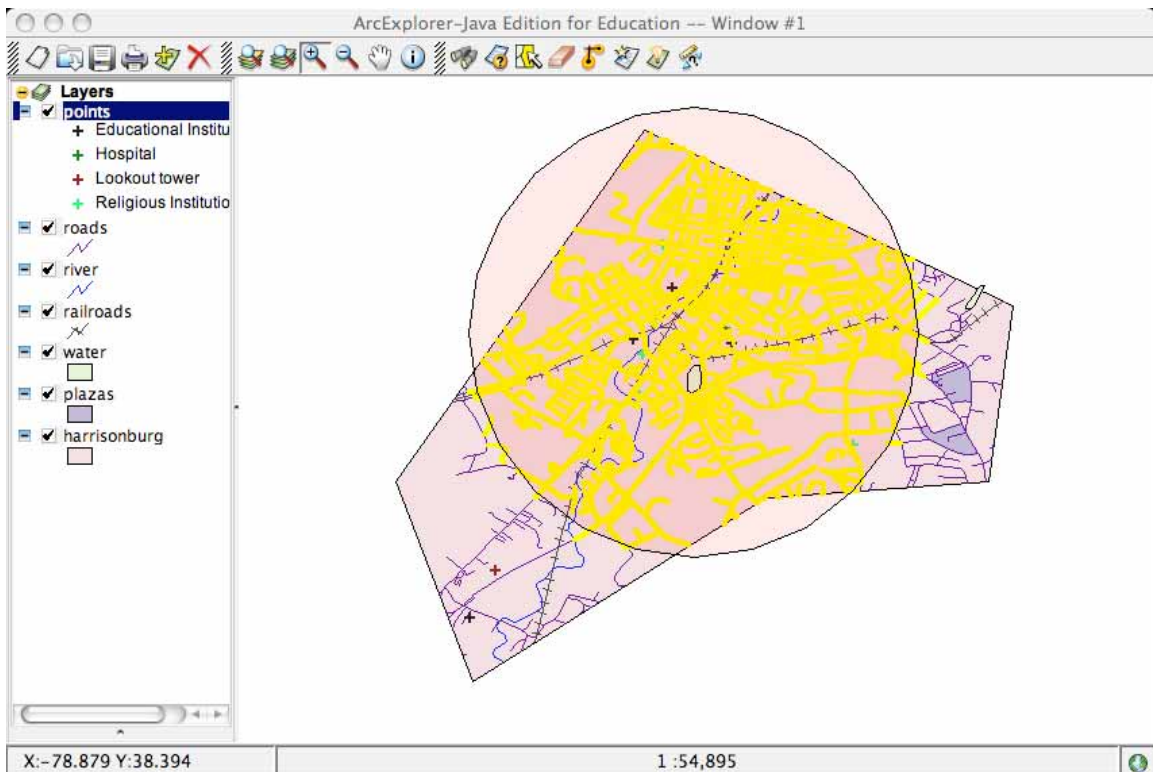


Figure 11. Screenshot from Maps for Decision Making. Students identify the college within this small city and use a 2 mile buffer to select all roads that need to be closed for security for a presidential visit. The roads within the buffer are highlighted in yellow.

Classroom Use

These activities help students develop spatial thinking and GIS skills as they study standard topics in the curriculum (latitude/longitude, earthquakes, etc.). They work both as entire class activities in a computer lab or as stations in a classroom. As with many technology-based activities, teaming students in groups of two can be very effective. Younger students working by themselves can sometimes struggle with reading directions, using the computer, and recording answers at the same time. When they work together, they can help each other and share the tasks, although the instructor needs to make sure that each student gets hands-on time with the computer.

The assessment for these activities has been designed to be very easy for the teacher. In most cases, you can observe the work of the students on the screen and ascertain whether the students have met the objectives of the activity. All activities can easily be completed within a class period and do not require the students to save their work. This makes life much easier in a networked school environment where saving student work can be the hardest step in using technology.

Conclusions

Geographic Information Systems software is a powerful data visualization tool that help students understand complex data by making maps and looking for patterns. Students can hone their critical thinking skills by using this software to make decisions about particular problems or issues. Public domain software is now available that runs on nearly all school computers, and a growing number of standards-based activities that easy to integrate into most classrooms are also available at no cost. These activities only represent a starting point and students and teachers can perform their own analyses using data they collect locally (or via the Internet). The ArcExplorer software opens a universe of possibilities for the upper elementary classroom and reinvigorates geography as a way of knowing. With GIS, you literally have the world in your hands.

Acknowledgements

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Appendix A – Relevant National Curriculum Standards

Imaginary Lines

Geography – (www.ncge.org - National Council for Geographic Education)

Standard 3: How to analyze the spatial organization of people, places, and environments on Earth's surface.

Mathematics – (www.nctm.org - National Council of Teachers of Mathematics)

Algebra (Grades 3-5) Understand patterns, relations, and functions

- describe, extend, and make generalizations about geometric and numeric patterns;
- represent and analyze patterns and functions, using words, tables, and graphs.

Geometry (Grades 3-5) Specify locations and describe spatial relationships using coordinate geometry and other representational systems

- describe location and movement using common language and geometric vocabulary;
- make and use coordinate systems to specify locations and to describe paths;

Where Are You

Geography – (www.ncge.org - National Council for Geographic Education)

Standard 1: How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information.

Standard 8: The characteristics and spatial distribution of ecosystems on Earth's surface.

Mathematics – (www.nctm.org - National Council of Teachers of Mathematics)

Geometry (Grades 3-5) Specify locations and describe spatial relationships using coordinate geometry and other representational systems

- describe location and movement using common language and geometric vocabulary;
- make and use coordinate systems to specify locations and to describe paths;

Geometry (Grades 4-6) Specify locations and describe spatial relationships using coordinate geometry and other representational systems

- use coordinate geometry to represent and examine the properties of geometric shapes;

Science – (www.nationalacademies.org - National Academy of Science)

Life Science (Grades K-4) Develop an understanding of organisms and environments

Life Science (Grades 5-8) Develop an understanding of populations and ecosystems

Current Quakes

Geography – (www.ncge.org - National Council for Geographic Education)

Standard 7: The physical processes that shape the patterns of Earth's surface.

Mathematics – (www.nctm.org - National Council of Teachers of Mathematics)

Algebra (Grades 3-5) Understand patterns, relations, and functions

- describe, extend, and make generalizations about geometric and numeric patterns;
- represent and analyze patterns and functions, using words, tables, and graphs.

Geometry (Grades 3-5) Specify locations and describe spatial relationships using coordinate geometry and other representational systems

- describe location and movement using common language and geometric vocabulary;
- make and use coordinate systems to specify locations and to describe paths;

Science – (www.nationalacademies.org - National Academy of Science)

Earth and Space Science (Grades K-4) Develop an understanding of changes in earth

Earth and Space Science (Grades 5-8) Develop an understanding of the structure of the earth system

Maps for Decision Making

Geography – (www.ncge.org - National Council for Geographic Education)

Standard 1: How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information

Standard 18: To apply geography to interpret the present and plan for the future.

Mathematics – (www.nctm.org - National Council of Teachers of Mathematics)

Geometry (Grades 6-8) Use visualization, spatial reasoning, and geometric modeling to solve problems

- Draw geometric objects with specified properties;
- Use visual tools to represent and solve problems;
- Recognize and apply geometric ideas and relationships in areas outside the mathematics classroom, such as art, science, and everyday life.

Geometry (Grades 3-5) Specify locations and describe spatial relationships using coordinate geometry and other representational systems

- describe location and movement using common language and geometric vocabulary;
- make and use coordinate systems to specify locations and to describe paths;

References

Kerski, J. (2003). The Implementation and Effectiveness of GIS Technology and Methods in Secondary Education. **Journal of Geography** 102(3), pp. 128-137.

Malone, L., A. M. Palmer, and C.L. Voigt (2002). **Mapping Our World**. ESRI Press, Redlands, CA.

National Council of Teachers of Mathematics (2000). **Principles and Standards for School Mathematics**. NCTM Press, Reston, VA.

National Geography Standards, published by the National Council on Geographic Education, <http://www.ncge.org/standards/>, accessed on 31 May 2005.

National Research Council (1996). **National Science Education Standards**. National Academies Press, Washington, DC.

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