During the fall, 2003 semester the Department of Geosciences at Stony Brook University piloted a new course, GEO 305: Field Geology, which was designed to provide undergraduates with an opportunity to learn field mapping techniques by engaging in projects on the University campus. The skills that students exercised through hands on experience during the course activities included making observations regarding the physical landscape, collecting detailed and accurate data in the field, and preparing maps and reports using a variety of data collecting techniques and software tools. Specific examples of assignments that students were responsible for completing included the mapping of: 1) trails in the Ashley Schiff Preserve, 2) ridges and valleys in the Ashley Schiff Preserve, 3) buried electric and water lines adjacent to the Earth and Space Sciences building, and 4) human-generated infrastructure in the vicinity of the Tabler Quadrangle Dormitories. During the early part of the semester, the students created their maps by hand. About midway through the semester, the students were introduced to ArcView 3.3 GIS software, developed by the Environmental Systems Research Institute, and they used it to complete subsequent mapping projects.

The students learned to map point features based on their geographic coordinates by first working with seismic event data downloaded from the United States geological Survey's National Earthquake Information Center. With minor modifications, they were able to load the data into ArcView as a comma-delimited text table. A portion of the table is shown in figure 1. Using the standard "Add Event Theme" item in ArcView's View Menu, the students added the data to a map with each event represented by a point. They were then able to represent the magnitude of the events with graduated symbol sizes and the depths of the events with color ramps.

<table>
<thead>
<tr>
<th>Year, Month, Day, Time, Latitude, Longitude, Magnitude, Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002, 01, 01, 003703.35, 19.30, -65.04, 3.7, 25</td>
</tr>
<tr>
<td>2002, 01, 01, 010701.50, -32.72, -73.01, 3.5, 23</td>
</tr>
<tr>
<td>2002, 01, 01, 023447.06, 37.22, -3.70, 1.5, 0</td>
</tr>
</tbody>
</table>
Having learned to add event themes to maps, the students could determine the coordinates of features in the field on campus, then map these features as event themes. They used this method to map points along trails in the Ashley Schiff Preserve with coordinates that they computed during a pace and compass exercise. The instructors provided the students with two custom-made menu items that were added to ArcView, and a custom-made Java application, in order to assist them with the mapping of features such as trails, ridges, valleys, and underground utilities, which are better represented as broken lines, or polylines, than as series of points. The menu items activated scripts that were written in ArcView’s Avenue scripting language. The instructors also provided an Excel spreadsheet for converting tape and compass coordinates in meters, with a specified origin, to UTM coordinates. Excel is a product of Microsoft Corporation. The custom "Add Trail Polyline" item that was created and added to ArcView’s standard menu by the course instructors invoked an Avenue script that created a polyline theme from a table of x (number) and y (number) attributes, and at least one other (text) attribute. The students used this to map trails and utilities. An example of hypothetical trail data that the students worked with to learn to use this feature is shown in figure 2. The names of the fields are delimited by tabs on the first line of the table. The data values corresponding to each field appear on successive lines, separated by tabs. Blank lines delimit groups of records, each of which creates one polyline when the script is invoked on the table.
The custom "Add Ridge Valley Polyline" item invoked an Avenue script that created a polyline theme from a table of x (number), y (number), bearing (number), length (number), and ftype (text) attributes. The students employed this item to map ridges and valleys in the Ashley Schiff Preserve. Example data that the students used to learn this feature is presented in figure 3 and a map created by a student appears in figure 4.

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
<th>bearing</th>
<th>length</th>
<th>ftype</th>
</tr>
</thead>
<tbody>
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<td>658188</td>
<td>4530039</td>
<td>127</td>
<td>190</td>
<td>valley</td>
</tr>
<tr>
<td>658397</td>
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<td>317</td>
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<td>ridge</td>
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<td>658302</td>
<td>4530088</td>
<td>301</td>
<td>117</td>
<td>ridge</td>
</tr>
</tbody>
</table>

For their utilities mapping assignment, the students needed to find the UTM coordinates of surface markers that represented the locations of buried electric and telephone lines. The instructors provided them with an orthoimage marked with the locations of reference
points with known coordinates (Figure 5). For each utility marker, the students could compute coordinates by measuring the distance to two of the reference points. The coordinates of the utility marker were computed as the intersection of two arcs that represented the locii of points that resided at the measured distances from their respective reference points.

Figure 5 - 1996 New York State orthoimage of the earth and Space Sciences Building vicinity with reference points.

The arc-intersection method used to compute the locations of the utility markers is illustrated by figure 6. The figure represents a hypothetical underground burrow system that the students used to learn this method. The locations of the numbered points were
computed using distances from known reference points, marked by letters. Arcs
representing the distances of one of the unknown points (point 4) from two reference
points (points a and b) are illustrated in figure 7. The computations of the coordinates of
the numbered points were performed by the Arc Intersection Calculator, a custom Java
application created by one of the course instructors and illustrated in figure 8. The Java 2
Software Development Kit was used to develop this application, and is available as a free
download from Sun Microsystems. To map the unknown points, the output from the Arc
Intersection Calculator was copied and pasted into a text editor or Excel spreadsheet, then
saved as a tab-delimited text file. From that file, it could be loaded into ArcView as a
table, and one of the standard or custom menu items could be invoked to map the table as
a point or polyline theme.
Figure 6 - Map of the hypothetical burrow system with tables used to create the map.
Figure 7 - The intersecting arcs are the locii of points that lie a specified distance from
two reference points (a and b) that have known coordinates. The known coordinates and distances were used to map the location of unknown point 4.

Figure 8 - The Arc Intersection Calculator Java application with hypothetical input and output data for the burrow system exercise.

At the conclusion of the course, several of the students reported that their experience with ArcView and the custom tools was helpful in enhancing their understanding of mapping techniques, since it provided an efficient method for rendering their data in a visual format. GIS software was beneficial because it resulted in accurate, more professional-looking maps than any that they were equipped to create prior to its introduction to the students during the semester. Its most valuable benefit to the class was its versatility. Objects could be added or removed from a map through menu items, the click of a
button, or the use of automated mapping tools. The program enabled them to add trees, ridges and valleys, and footpaths to an area map that was otherwise very difficult to create by hand. This allowed them to have all the information easily available, while they focused on specific aspects the map at any given time. The students could query, analyze and symbolize their data in a wide variety of ways in order to create their maps. In addition, the GIS software provided them with the ability to create multiple maps almost instantaneously. A major asset of ArcView 3.3 is that it is quite user-friendly, and therefore requires only a short learning curve on the part of the students for mastering the basic functions. It provides tools for adding accessory documentation to maps, including a scale, legend, text and north arrow or compass. In mapping assignments completed prior to the introduction of GIS to the course, this supporting documentation was produced by hand and resulted in problems such as incorrect scales and sloppy legends. GIS and other digital tools enabled students to expedite much of the repetitive tasks associated with analyzing data and creating maps so they could devote the bulk of their effort to exercising their higher order problem solving skills.

References

Environmental Systems Research Institute (ESRI) http://www.esri.com

Microsoft http://www.microsoft.com

National Earthquake Information Center http://neic.usgs.gov/

Sun Microsystems http://www.sun.com