Sidewalk and Pathway Analysis: A Walk around Campus

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Abstract: This paper will discuss engagement of students in a network analysis project, which involved modeling campus sidewalks and pathways. Students were divided into groups to digitize all sidewalks and pathways in their selected area on campus. Once finished, they exchanged their data with each other and connected each other's datasets to participate in a network analysis. Next, they were responsible for creating service areas in one-minute intervals (up to five minutes) for each of the student-classified parking lots on campus. Finally, they created a large-format map showing these areas on campus.

1. Introduction

The Department of Geography and Geology at Western Kentucky University in Bowling Green, Ky. offers several programs in GIS: Certificate in GIS; Graduate Certificate in GIScience; GIS Minor; GIScience Major; GIS and Spatial Analysis Track in the Geography Major; and a GIS and Spatial Analysis Track in the Geoscience Master's Degree. The Department of Geography and Geology has its own GIS facility which is equipped with two 21-seat computer classroom labs and a Center for GIS (with nine computer workstations that are dedicated to research and GIS projects). WKU has had an ESRI university site license since the year 2000 and these labs are well equipped with a suite of ESRI products. The labs also contain other GIS related software, such as Trimble's Pathfinder Office and ERDAS Imagine Pro. There is a total of 19 GIS courses taught in WKU's GIS program (WKU Center for GIS, 2006). This paper will discuss a project in one of those courses, which is *GIS Modeling and Analysis*.

GIS Modeling and Analysis (GEOG 417(G)) is a senior level course that can be taken for graduate credit. This course is required in all programs mentioned above. The following is a description of that course (WKU Center for GIS, 2006):

> "This course develops expertise with a broad range of spatial analysis and Modeling functions using GIS. A problem-oriented approach stresses the utility of GIS analysis to fields such as agriculture, business, natural resource management, and urban planning. The objectives of this course are: (1) to develop working familiarity with digital spatial data sources, types, and access issues, (2) to develop working knowledge of spatial analysis functions supported by a GIS, (3) to develop competency with cartographic modeling using desktop GIS software, and (4) to develop experience with production and presentation of a GIS project."

The classroom project for this course is focused on creating service areas (i.e., distance maps) from each student parking lot on WKU's main campus in minute intervals up to five minutes along sidewalks and pathways. Students used GPS and GIS to arrive to the final results. The final results displaying these areas on campus are presented in a large-format map.

2. The Project

The prerequisites for this course are both *Fundamentals of GIS* (GEOG 217) and *Geographic Information Systems* (GEOG 317). So already, students have had at least six credit hours of GIS prior to taking this course. The project's focus is to develop independence as an individual in utilizing GIS and to work with each other as a group as well as working with other groups. This paradigm simulates a real-world project in a working environment. In addition, each student produced a technical report of the project. The goal of this project is to create service areas around each of the student parking lots on the main campus. Service areas are produced along sidewalks and pathways in one minute intervals (in regards to an average walking speed) up to five minutes.

This project is to be completed in a six-week period and there are limitations to this project as well. Students are to assume that the main campus of WKU is flat, but this is not the case at all. One end of the main campus, where most of the classes are taught (to the far right in Figures 1 and 2), is positioned on top of a hill; hence, WKU Hilltoppers. This trek to the top of the hill can be exhausting and tiresome, particularly to those who are new to this campus. The other constraint is data, which also led to one of the challenges of this project. The only data available to them are five-year old, ½ foot resolution orthophotos, building footprints, and road center-lines. The only missing data are the sidewalks and pathways, which are needed to create the service areas from the student parking lots.

Figure 1
Main Campus of WKU and Group Quadrants.

Most of the data for the sidewalks and pathways are to be collected with a GPS unit and some of that data are digitized with on-screen digitizing techniques. The class of 18 students is divided into four groups. Each group is assigned a “quadrant” of campus in which they are responsible for digitizing (see Figure 1). The quadrants are delimited in an effort to be fair in regards to the amount of data collected along with its challenges. Students used Trimble’s GPS Pro XRS and Timble’s TSC1 datalogger for collecting points for the sidewalks and pathways. For the on-screen digitizing process, ArcGIS (ArcInfo license) 9.1 is used to complete this task, particularly ArcMap.

Each group differentially corrected all of the raw GPS data collected from the field with Trimble’s Pathfinder software and then exported it to a shapefile to be further corrected as well as connecting it to pre-existing data via ArcMap. For this project, groups had a choice in working with and submitting their datasets as a shapefile or in a geodatabase. (Only one group choose to do it in a geodatabase.) After each group's geospatial data of sidewalks and pathways is finalized to their expectations, their data is then shared among each other to be connected for the entire main campus area.

Once their datasets are connected and topology implemented, their next task is to create service areas for each student parking lot along sidewalks and pathways in one minute intervals (in regards to an average walking speed determined by the group) up to five minutes. The service areas are created in ArcGIS Network Analyst.

Figure 2
WKU buildings (Red) and student parking lots (Green).

Finally, each group created a large-format map that focused on the service areas around each student parking lot. At least one dimension of their map had to be 42". For most students, if not all, this is their first time designing a large-format map. As a result, they could see first hand the errors and how the design translated over from a monitor to a large-format print.

3. Preparing the Students for the Project

This project is conducted in the last five weeks of this course (a 15-week course in the fall semester). Leading up to that point, a series of preparations is carried out on top of the course lectures. Each student turned in their own GPS exercise, which is not part of this project, of a point, line, and polygon feature of their choice along with a data dictionary and exported shapefiles after they had been differentially corrected. This is to assure the instructor that they are able to utilize the GPS unit without having to rely on a group member to do all the work; they are graded accordingly. The submission of their own GPS exercise are on a CD with files and folders stored logically (i.e., good file management). Prior to this course, they are introduced to the hand-held GPS units, but now they are being introduced to the mapping/surveying grade units.

Figure 3
Group digitizing sidewalks with GPS

In this course, students are introduced more extensively to topology. They completed the following ESRI Virtual Campus courses for preparation, which is part of our ESRI University Site License package: *Creating, Editing, and Managing Geodatabases for ArcGIS 9; Creating and Editing Geodatabase Features with ArcGIS 9.0 – 9.1 (for ArcEditor and ArcInfo)*; and *Creating and Editing Geodatabase Topology with ArcGIS 9.0 – 9.1 (for ArcEditor and ArcInfo)*. After completing these online courses, students were given an assignment to independently build a geodatabase of Warren County's census feature classes in accordance with the Census-Administrative Boundaries Data Model (ESRI, 2006).

4. Software and Data Utilized in this Course

For the GPS portion of the project, Trimble's Pathfinder Office is used for creating data dictionaries, downloading the raw data, differentially correcting the raw data (with Barren River Area Development District base station, which is about 7 miles away), and exporting corrected data to a shapefile. Trimble's Asset Surveyor is the software loaded in the Trimble TSC1 datalogger, which was used out in the field for data collection. WKU also has an ESRI University Site License, which includes ESRI Virtual Online Courses, ArcGIS (ArcInfo) Desktop software and ArcGIS Network Analyst.

The ESRI Virtual Online Courses mentioned above are the only courses issued during the semester. ArcCatalog is used extensively for GIS data file management, creating both feature classes and shapefiles, and creating geodatabases and topology. ArcMap is mostly used for data correction and map creation. ArcGIS Network Analyst is used in both ArcCatalog for creating a network dataset and ArcMap for creating service areas. Corel Draw is used to add some final touches to their large-format map. Microsoft's Windows Explorer is used extensively for the "behind-the-scenes" file management.

For the project, students are provided with the following data: ½ foot 2002 "black & white" orthophotos and building footprints used for WKU's campus were provided by the City of Bowling Green. Warren County road center lines are provided by Barren River Area Development District. Additional data as an option are provided by the Kentucky Division of Geographic Information, such as the 2005 color orthophotos used in Figures 1 and 2.

5. Challenges of the Project

The definition of GIS "…is a computer system [used] for capturing, storing, querying, analyzing, and displaying geographically referenced data" (Kang-tsung Chang, 2004). The challenges of this project will be broken down into the following sections with respect to the definition of GIS: (1) storage and retrieval of data; (2) collection, correction, and input of data; (3) manipulation and analysis; and (4) maps and technical reports.

Figure 4
Students working on their project in the GIS Lab.

5.1 Storing and Retrieving Data

Each group developed some means of having a centralized location of storing and retrieving data for their project. It was common for them to choose one computer in the GIS lab for that centralized location. In all cases, students learned rather quickly to back-up their data and project files (.mxd). A system of communication (e.g., email, phones) is developed because of group members working on their project at different hours of the day and/or different days due to their class schedules and where the lived.

5.2 Collection, Correction, and Input.

In order for the service areas to be created, the line feature class of the sidewalk and pathways are digitized and prepped for ArcGIS Network Analyst.

5.2.1 GPS

The majority of the data capturing is through the Trimble GPS unit. First they decided on how to set up their data dictionary (i.e., what attributes would be needed while out in the field) and determine their data collection interval for capturing feature vertices. Once out in the field, it is almost a straight forward process when walking along the sidewalks, but it's determining what could be used as a pathway that became difficult.

Once back in the office, it is a matter of uploading it to the computer to be differentially corrected in Trimble's Pathfinder Office. After satisfied with the outcome of the dataset, they then exported the data (.cor) into a shapefile to be viewed and further examined and corrected in ArcMap. They had to keep in mind that it is important for them to export the different attributes that the datalogger collected out in the field, such as DOP values and time of day, for future references. One problem they often came across is that Pathfinder Office didn't always export a clean shapefile, i.e., the geometry often became corrupted. (The obvious fix was to use the Repair Geometry tool in ArcToolbox, but it never worked. Fortunately, we inadvertently found a cure: to import the shapefile into a geodatabase and then export it back out into a shapefile.)

It took several trips out in the field to digitize their area and the challenge was communicating what had been done and what needed to be done. Furthermore, connecting and/or merging the datasets into one complete dataset presented some challenges because of communications between group members on the areas that needed to be further examined.

5.2.2 On-Screen Digitizing

On-screen digitizing was used mostly for straightening out the zigzag like pattern along a straight sidewalk and connecting junctions at intersections while using orthophotos in the background. It is also used to planarize the line features where it needed to be "cracked." Further on-screen digitizing is used after ArcGIS Network Analyst is unable to create service areas; this basically meant that some line feature's end points (i.e., node) did not snap or was not planarized correctly. In addition, line features are stretched to snap to building footprints and the parking lot's perimeter. The length field of the line feature data set had to be updated as well by using the following code in the field calculator (ArcGIS Desktop Help):

```
Dim Output as double
Dim pCurve as ICurve
Set pCurve = [shape]
Output = pCurve.Length
```

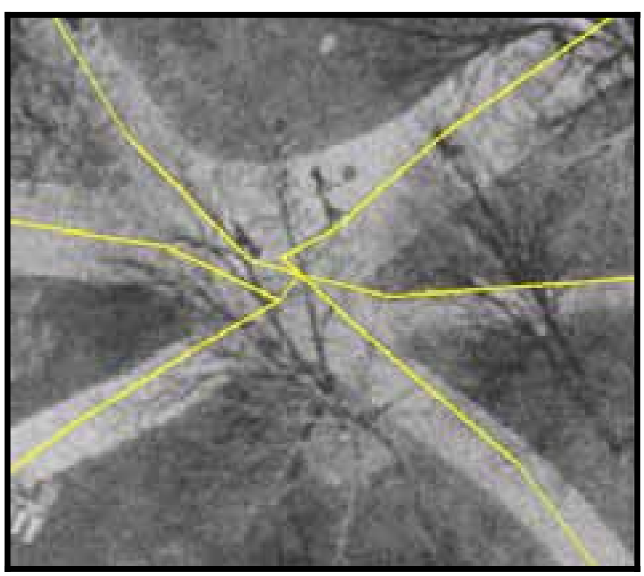

Figure 5
A typical intersection before correction in ArcGIS.

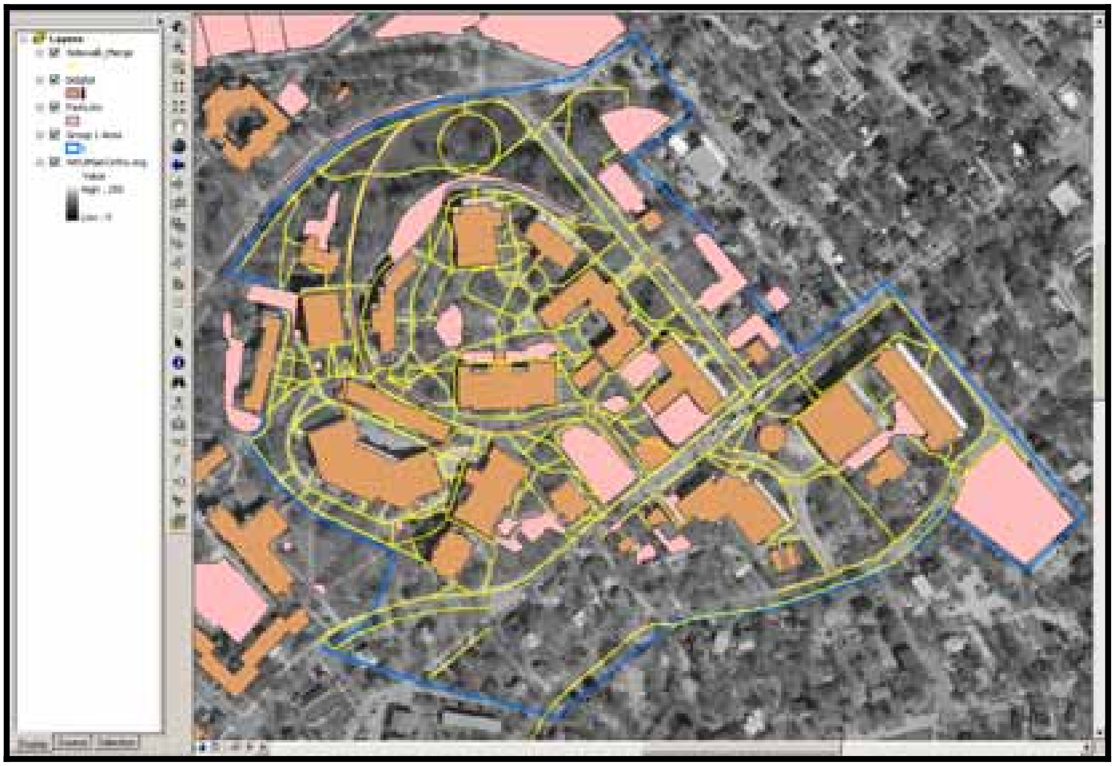

Figure 6
An example of a group's area with their group's boundary (blue), building footprints (light red), parking lots (dark orange), and digitized sidewalks & pathways (yellow),

5.3 Manipulation and Analysis

Once the groups' dataset are connected, creating service areas for each student parking lot is the next step. ArcGIS Network Analyst is utilized to produce these areas. In some cases, datasets are not contiguous and had to be edited further and, in other cases, areas needed additional pathways digitized, such as crossing a road or traveling through an alley way. Since only sidewalks and pathways on WKU's main campus are digitized, service area polygons created for the student parking lots are jagged and misleading for areas outside due to the "guess work" of ArcGIS Network Analyst. As a result, additional fine tuning of the polygons generated was suggested to students for cartographic purposes.

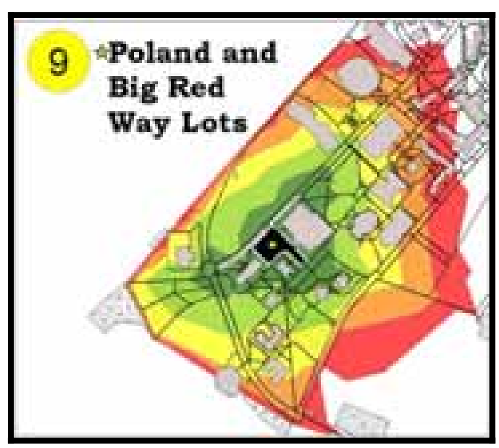

Figure 7
Example service areas in one-minute intervals up to five minutes.

5.4 Maps and Reports.

For their final presentation of their results, a large-format map and technical report of their project is to be generated. The large-format map had to have at least one dimension with length of 42”. Students designed their map as if they are producing a map that would be used by students alike on campus. For most students, if not all, this is their first time creating a map of considerable size. Using the 1:1 feature for the layout in ArcMap is highly recommended for they would not have a second chance in printing out their map due to time constraints of this project. One map is produce per group.

Their technical report is about the project from start to finish. Each student is responsible for producing their own detailed report and not one report per group. There is no page limit to their report and the average range in the number of pages submitted by each student was around 15 to 20. Figures are highly encouraged to be utilized throughout their paper.

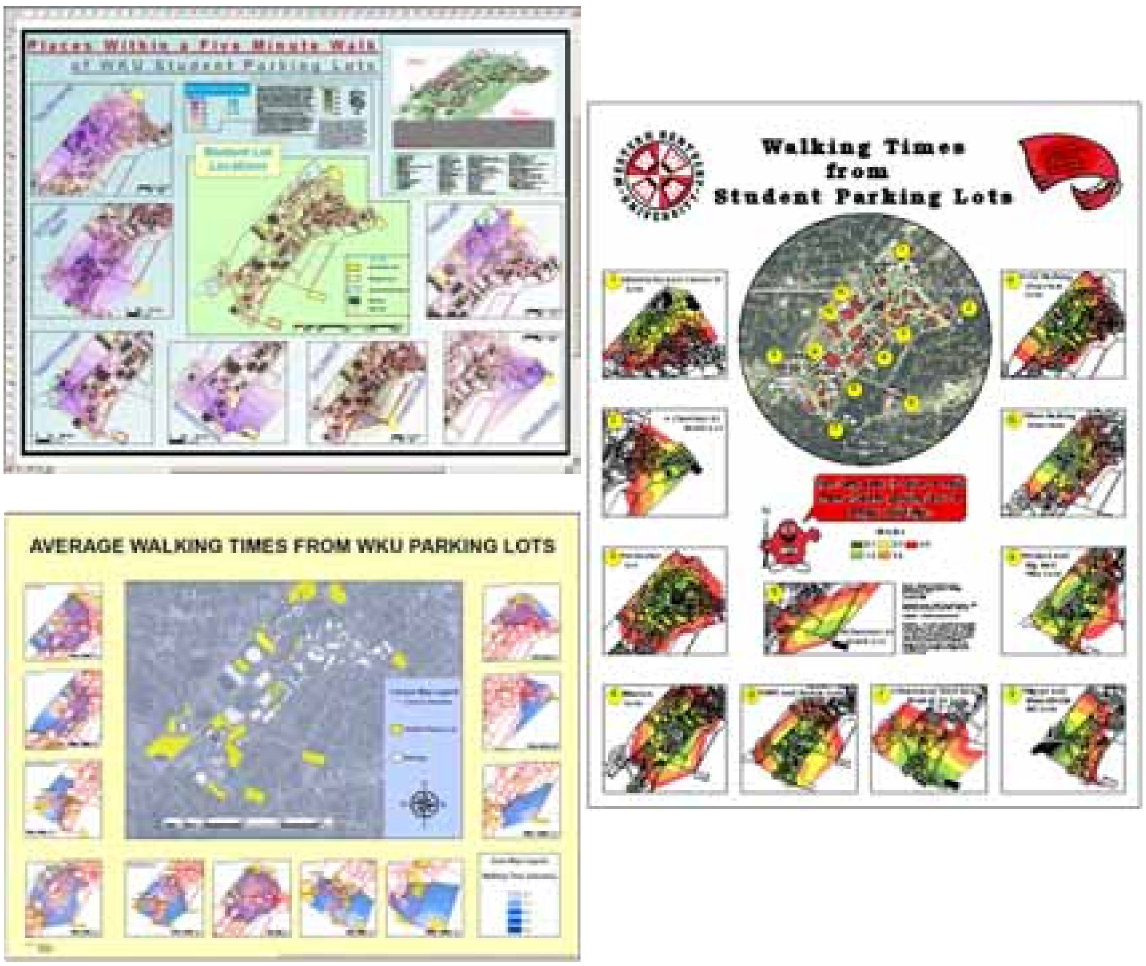

Figure 8
Examples of maps produced by groups.

6. Conclusion

Courses prior to this one focused on each component of the definition of the GIS (i.e., a lab per component). This lab project focused on the definition of GIS in its entirety while having students working together. Students are able to experience each component and the transitions from one component to another resulting into refining their understanding and appreciation of each. Whether the students are pursuing GIS as a tool or a profession, they were able have insight of a GIS project to this magnitude and an appreciation of one another. It also allowed them to foresee the importance of an enterprise GIS without having to use one.

This project also brought about developing user expertise in the students as well as having to rely on their abilities and knowledge to accomplish this project. As mentioned before, the goal of this project is to develop independence and confidence within each student to carry out a real-world project. Troubleshooting different scenarios are challenging, but at times it is out of their control in which resulted in having the instructor troubleshoot some of their problems. But it is important to mention that the level of GIS and GPS user expertise is high for the instructor in order for this project to move smoothly because of unanticipated problems. Furthermore, availability of the instructor to the students while this project is undergoing is very important (i.e., available at all times, which is very tough).

Overall, this project is a great project for engaging students in a classroom setting in real-world scenarios. It allows them to understand the need of user expertise, as well as experiencing what it is like to work with others on a GIS project whether it is group members like co-workers or other groups like GIS organizations. From these experiences, they understand the need of being reliable and to develop expectations of supplementary data produced by other GIS Analysts.

7. References

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