ABSTRACT
Dr. Anne Kelly Knowles keynote presentation at the 2008 ESRI Education Users Conference got me thinking about how historical maps could be used to develop a transportation database for a local area and to help students to understand the local environment. Therefore I developed a student exercise in head-up digitizing; it would make students familiar with “old” maps as a source of information to build a geodatabase. Specifically, using the 15-minute topographic map series for Allentown (1894), Slatington (1902) and Hamburg (1911) the road, railways and street railway networks were built for the area between Allentown and Reading, Pennsylvania. This area includes Kutztown University which the students are attending. The processes and procedures used in this laboratory exercise are discussed as well as how the “old” data is compared with “modern” data.

INTRODUCTION
Most students in GIS courses become very familiar with modern digital data sources such as tax parcels, digital elevation models, hydrologic data models, and street/transportation networks. However, Dr. Anne Kelly Knowles keynote address at the ESRI Education Users conference in 2008 got me thinking about incorporating historical maps into a geodatabase. This paper discusses an exercise I used in my Advanced GIS class to incorporate historical maps as a sources of transportation data features, specifically roads and electric street railways/trolleys in the Kutztown area. Following a discussion of the historical map sources, the digitizing process will be briefly defined. Then a comparison of the resulting data sets is discussed and differences are noted between the data from the historical maps and modern map data. The paper concludes with a short discussion on how these historical maps may be used to improve our understanding of the past.

DATA SOURCES
Three 15-minute USGS topographic maps from the end of the nineteenth century and early twentieth century were used in this student exercise. These maps were downloaded from the Pennsylvania Spatial Data Access site [1]. Specifically the maps were the Allentown 1894, the Slatington 1902 and the Hamburg 1911 quadrangles. As stated in the metadata the “Historic USGS 15 minute topographic maps for Pennsylvania as collected from the MapTech Historical Map Collection at 'http://historical.maptech.com'. Scanned map images from MapTech were downloaded, assembled, and registered and rectified via Arc/Info to the UTM Zone 17/18 NAD83 projection”[2]. In addition, digital vector road files from the Pennsylvania Department of Transportation and digital orthophoto quarter quadrangles from the U.S. Geological Survey were used as part of the exercise.
DIGITIZING THE ELECTRIC STREET RAILWAYS

Using the three 15-minute topographic maps the students were initially to digitize the major transportation features between the cities of Allentown and Reading, Pennsylvania. The primary emphasis was on the electric street railways, roads and steam railroads. The spatial extent of the study quickly collapsed to include only the area between Kutztown and Allentown because of data problems which are discussed below.

Starting in the area of the Borough of Kutztown, the street railway right-of-way was digitized. See Figures 1, 2, and 3. In addition, a number of the local roads were digitized to provide a reference to the present road network. The students were quite surprised by the number of roads that were depicted on the old maps which they were driving on today. The students followed the path of the Allentown and Kutztown Electric Railroad eastward to Allentown. Initially the primary problem noticed by the students was edge matching the topographic maps. I had the students digitize the street railway and the surrounding roads as they appear on the sheets and told them that we would edge match and/or edit the differences later. A much less significant problem was following the street railway right-of-way because of the quality of the maps or their scanned images.
Once the trolley line and the period roads were digitized, the students brought into their maps the present-day local and state road network. In overlying the digitized period features with the modern road network, a number of differences became apparent such as Main Street, see Figure 4. By overlaying the digitized period roads and the modern digital road network on a recent DOQQ, it was apparent that digital files for the modern
roads were in the correct location while the digital period roads were out of place, see Figure 5. Thus a project that had started out as providing the students with more practice in heads-up digitizing quickly became a project in reinforcing the students experience in spatial adjustment. It was also realized that digitizing the area westward between
Kutztown and Reading would provide similar problems and therefore this area was dropped from the exercise.

SPATIAL ADJUSTMENT
The digitized period street railways and roads were clipped into approximately quarter quadrangles for the study area. This allowed each of five groups of students to spatially adjust one area. The Kutztown area was done as a class to make sure everyone was up to speed on spatial adjustment. Using the modern road network as the base reference, a series of adjustment links between the period features and the modern features were determined and an affine transformation was applied. Two examples are shown in Figures 6 and 7. These spatial adjustments represent the two ends of the distribution of the root mean squared error which ranged from a high of 43.4m to a low of 6.4m. Therefore none of the spatial adjusted trolley network sections were acceptable for building a geodatabase.

While the results were poor, it did generate some very good classroom discussion points of why these problems existed. The points that were raised by the students included working with differently scaled data; map simplification and generalization; errors in the original maps; errors that may develop from scanning, merging and georeferencing the original maps; and changes that may have occurred over the decades on the original medium of the maps.
RESULTS AND CONCLUSIONS
To resolve the problems with the historical maps, the digitized period street railway and roads files were discarded. Instead the historical maps were used in conjunction with DOQQ’s and digital files of the modern road network to locate the route of the Allentown and Kutztown Electric Railroad. This produced a much better representation of the location of this system right-of-way, see Figure 8. Most of the route could be mapped easily since many of the roads are still in use, although some modern structures have obscured the right-of-way in the area of Allentown. Since this was not an exercise in ‘deep’ historical research, the problem is left to later researches.
The exercise as initially planned was to be done in a single two-hour laboratory period. However, with the differences between the modern and period network needing to be resolved, an additional two-hour lab was necessary. In general the students found it to be a very useful exercise. They became more familiar with heads-up digitizing and spatially adjusting data. They also found that the old maps may be useful, provide you are aware of their limitations and you check them against reliable sources. In the future this exercise will be more limited in its spatial extent and the focus will be on the problems associated with historical data sources.

REFERENCES

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