INTEGRATING GEOSPATIAL TECHNOLOGIES INTO K12 STEM EDUCATION – A SWOT ANALYSIS

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Tennessee STEM Education Research Conference – February 2, 2017
From This...
To This...

NARCCAP Model Pairs for Freight System Hot Spot Analysis
Frequency of Daily Average Precipitation over 2”

Social and Environmental Change in Bangladesh
Sponsor: Office of Naval Research (ONR)

- Developed protocols and mobile applications for data collection in remote areas with geolocation capabilities
- Developed sampling plans
- Guiding development of web-based GIS integration platform for social and physical science data
The Basics - What is GIS?

**Geographic Information Systems (GIS)** - A powerful set of tools for storing and retrieving, transforming, analyzing and displaying spatial information for a particular set of purposes.

GIS Features

- Geographic data as themes or layers in the computer
- Layers linked to a common georeferencing system
- Each layer has attribute table with data behind it

Applications

- Google Maps, Bing, Zillow, Lyft, Uber, MapQuest, Urban Spoon, Yelp, Tax Parcel Data, Twitter, Facebook, UPS, FedEx, Amazon, etc.
Geospatial Technology (GT) is Everywhere!

http://geospatialrevolution.psu.edu/trailer.php
Geospatial Technologies (GT) Concept Map

Geospatial Technology Applications

- ArcGIS Desktop
  - Complete system used for creating maps, managing data and performing analysis – PC Only

- ArcGIS Online (Org)
  - Cloud-based collaborative content management system with some analysis capabilities – Any Operating System

- ArcGIS Explorer (FREE)
  - Web-based and downloadable mapping software with some analysis capabilities – PC Only

- Google Earth™ (FREE)
  - Cloud-based mapping system with NO analysis capabilities, 2GB storage free – Any Operating System

Complexity

- ArcGIS Online (FREE)
  - Global imagery viewing software including 3D buildings and terrain – Any Operating System

- ConnectEd
  - Complexity FREE through ConnectEd
My Hypothesis/Passion

Use of GIS/GT in K12 Classrooms can lead to the following:

- Exposure to real-world, hands-on learning experiences utilizing technology commonly used by professionals
- Engagement in the learning process by different learner types
- Development of critical spatial skills of future STEM professionals
- Improved problem solving and communication skills
- Increased awareness of STEM career opportunities
SWOT Analysis for GT in Education

- Strengths
- Weaknesses
- Opportunities
- Threats
Strengths
Geospatial Technologies and STEM

- ecology, green energy, environmental management, biology, geology
- computerized mapping, managing various data sources and types, satellite imagery
- problem solving, design, analysis
- geometry, spherical coordinate systems, units of measurement
Benefits of GT in Education

- Provides a new, more visually appealing and engaging way for teachers to present information to students
- Ideal for **project-based learning (PBL)** activities
- Hands-on learning
- Connects classroom learning to real world activities
- Multi- and interdisciplinary applicability
- Creates opportunities for collaboration (K-12, Higher Ed, Industry)
The Geographic Inquiry Approach – Aligns with Project-Based Learning (PBL)

**Ask**
- Where is there an unmet need for tornado warning sirens in my community?

**Acquire**
- Existing Siren Locations
- Siren Range Data
- Population Information

**Examine**
- Which areas currently have siren coverage?

**Analyze**
- Which areas do not have coverage?
  - Does the population in those areas warrant sirens?
  - Where would sirens need to be placed to provide coverage to those areas?
  - Is there public property available for siren placement?

**Act**
- Identify possible locations for siren placement
- Write proposal to local government for sirens to be installed or grant to help fund new sirens
- Which areas do not have coverage?
- Does the population in those areas warrant sirens?
- Where would sirens need to be placed to provide coverage to those areas?
- Is there public property available for siren placement?
Using GIS in the Classroom

- Field Data Collection to Support Class Projects
  - GLOBE Program - https://www.globe.gov/
  - GPS and Mobile Devices with ArcGIS Online/Desktop

- ESRI Story Maps
  - Prompt student lessons through independent discovery
  - Students create online, visual “reports” – Example: **Sonora Elementary 4th Graders in Springdale, Arkansas**
Instructional Use of GIS

Level | Features
--- | ---
1 | Presentation or demonstration
   - The teacher conducts a carefully planned presentation with GIS to highlight facts or concepts or to demonstrate a process
   - The teacher can employ an interactive style of questioning and prompting to guide student discovery and coordinate content
   - The group goes through the experience together
2 | Scripted activity
   - Teacher and students follow a set of precise instructions to explore a modest set of information about a topic or a place, learn facts or concepts, experience a process or see that GIS can help answer a question
   - The data, procedures, and questions are provided, and the movement tends to be linear toward a predetermined result
   - The script may support analytical thinking, but questions not central to the activity’s mission are avoided in order to focus the instruction
3 | Expanded script
   - Having explored sets of data with GIS, teacher and students go outside the bounds of the instructions and questions from one or more scripted activities, following their own ideas with the provided resources
   - The teacher may provide the question to explore, or teacher may provide general context with a realistic but broad strategy to provoke greater analytical thinking by students
   - The mission is to open up the doorway for students to customize their explorations, strategies, analyses, and interpretations
<table>
<thead>
<tr>
<th>Geospatial Technologies Aligns with Core Content Standards</th>
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<thead>
<tr>
<th>Science and Engineering Practices (Grades 6-8, 9-12)</th>
<th>Students may hypothesize about human activity impacts to the environment and test this through data collection using GPS units, scientific equipment, and GIS software.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Studies- Process Standards (Grades 6-8, 9-12)</td>
<td>Students may explore the world using Google Earth, online mapping resources, and create their own maps using data from the local community to examine changes.</td>
</tr>
<tr>
<td>Mathematics - Process Standards (Grades 9-12)</td>
<td>Students may represent situations and solve real-world problems using symbolic features and algebraic expressions to analyze data in the attribute tables of GIS.</td>
</tr>
<tr>
<td>World Geography - Process Standards (Grades 9-12)</td>
<td>Through use of geospatial technologies such as Google Earth, students can visit other countries without leaving the classroom.</td>
</tr>
<tr>
<td>Culture</td>
<td>One of the key data layers often utilized in GIS analysis is U.S. census data that includes average household income and other demographic properties. Geospatial technologies can be used to identify/evaluate food deserts, under served populations and at risk populations.</td>
</tr>
<tr>
<td>Economics</td>
<td>Inherent in geospatial technologies is geography. Everything and every person occupies some element of space and this location as well as the natural and man-made features around us can be mapped using the software technologies for analysis.</td>
</tr>
<tr>
<td>Geography</td>
<td>The drawing of political boundaries has long been an outcome of spatial data analysis using geospatial...</td>
</tr>
</tbody>
</table>
Supporting Research

- “The available evidence supports the claim that spatial training could improve STEM attainment, but not for the reasons that are commonly claimed. The reason spatial abilities matter early on is because they serve as a barrier; students who cannot think well spatially will have more trouble getting through the early, challenging courses that lead to dropout.” - David H. Uttal and Cheryl A. Cohen (2012)

- “While spatial ability measures correlate with science, technology, engineering, and math (STEM) success, a focus on spatial thinking is all but missing in elementary school education.” - Holly A. Taylor & Allyson Hutton (2013)

- “What is interesting is that the standardized FCAT reading test results, and science and social studies grades appears to corroborate the students’ perceptions that GIS and GPS integration enhances their learning.” – Donna Goldstein (2010)

- “This study is only a first step in discovering and understanding the connection between GIS learning and spatial thinking ability, its results do have some practical applications...the statistical analysis and the student comments support the notion that hands-on, lab- or project-based experience improves students’ spatial thinking.”- Jongwon Lee & Robert Bednarz (2009)
Ongoing Efforts

- Teacher professional development/training workshops
  - Since 2011, over 13 professional development workshops for teachers in Middle Tennessee and beyond
  - Past workshop sponsors:
    - Metro Nashville Public Schools
    - Middle TN STEM Hub
    - TN Department of Education
    - ESRI, Inc.

- Others involved in GIS education efforts
  - Leah Keith (Red Bank High School) with Randal Hale, North River Geographic Systems, Inc.
  - Stephanie Ivey, University of Memphis
  - Neil Jobe, GeoJobe - MapThis
  - Tim Prather, UT Knoxville - 4-H Map Competition
  - Kurt Butefish, UT Knoxville
  - Pat Worth, Roan State Community College
Opportunities
Positive Career Projections

• **One of the Top 3 Emerging Fields** behind nanotechnology and biotechnology
  ([http://www.careervision.org/about/Emerging_Career_Fields.htm](http://www.careervision.org/about/Emerging_Career_Fields.htm), 2013)

• What is driving this growth?
  - GT provides a new way to view, analyze, and present information (More visually appealing)
  - Better understanding => Better decision making => Operating more efficiently

• Demand for GT professionals is not being met
  - Shortfall is estimated at 3,000 – 4,000 people per year in the U.S. alone. (Board on Earth Sciences and Resources, 2006)
  - Market is growing at an annual rate of almost 35%, with the commercial subsection expanding at the rate of 100 percent each year (Geographic Information Technology Association)
ArcGIS Users for K12 Educational Purposes in TN

Past or present K-12 ArcGIS Educational License Holders

66 ArcGIS Online Organizational Account Holders

Potential Future K-12 ArcGIS Educational License Holders through TSIN
ESRI and ConnectEd

FREE ArcGIS Online Organizational Accounts for K12 Education – Nationwide!

The ConnectED initiative and Esri:

Open Doors to Many Careers

Give students future options with high-value skills in problem solving, data analysis, and technology integration.
## Introduction to Geographic Information Systems (GIS)

<table>
<thead>
<tr>
<th>Primary Career Cluster:</th>
<th>Science, Technology, Engineering, and Mathematics (STEM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consultant:</td>
<td>Deborah Knoll, (615) 532-2844, <a href="mailto:Deborah.Knoll@tn.gov">Deborah.Knoll@tn.gov</a></td>
</tr>
<tr>
<td>Course Code(s):</td>
<td>6142</td>
</tr>
<tr>
<td>Prerequisite(s):</td>
<td>Algebra I (0842, 3102) and Geometry (0843, 3108)</td>
</tr>
<tr>
<td>Credit:</td>
<td>1</td>
</tr>
<tr>
<td>Grade Level:</td>
<td>11-12</td>
</tr>
<tr>
<td>Graduation Requirements:</td>
<td>This course satisfies one of three credits required for an elective focus when taken in conjunction with other STEM, IT, Architecture &amp; Construction, or Agriculture courses.</td>
</tr>
<tr>
<td>Programs of Study and Sequence:</td>
<td>This is an optional elective to support multiple programs of study.</td>
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</tbody>
</table>
| Aligned Student Organization(s): | SkillsUSA: [http://www.tnskillsusa.com](http://www.tnskillsusa.com)  
Tracy Whitehead, (615) 532-2804, Tracy.Whitehead@tn.gov  
Technology Student Association (TSA): [http://www.tntsa.org](http://www.tntsa.org)  
Tracy Whitehead, (615) 532-2804, Tracy.Whitehead@tn.gov |
| Coordinating Work-Based Learning: | Teachers are encouraged to use embedded WBL activities such as informational interviewing, job shadowing, and career mentoring. For information, visit [https://tn.gov/education/topic/work-based-learning](https://tn.gov/education/topic/work-based-learning). |

Currently being offered in one county with enrollment of about 15 students.
Weaknesses and Threats (i.e., Challenges)
States and Districts with Statewide GIS Desktop Licenses for K12 Education
Threats and/or Challenges

- Lack of Support
  - Administrative for teachers to participate in PD (often competes with other PD requirements)
  - IT
    - ArcGIS Online only requires internet, but still some have issues with limited bandwidth
    - ArcGIS Desktop requires Windows, 10GB storage, and RAM
  - Financial – funding to support teacher training and track students

- Lack of Information
  - Teacher knowledge
    - New GIS high school course
    - Where to get training and access to resources
    - GT professionals in area (GeoMentors)
  - GIS Community
    - How to work with teachers and students at appropriate levels
    - Knowledge of teachers who would like support
Success Stories
Students Engaged in Learning with GT
4-H GIS Competition through TNGIC

- Tennessee Geographic Information Council
- 4-H students across the state
- Winners go to ESRI User Conference (~14,000 participants)
Recreating History Using Spatial Skills

A couple of years ago, the Obama’s ConnectEd initiative provided schools with the opportunity to have free access to the online GIS mapping tool ArcGis. I jumped on the opportunity not realizing that the learning curve would be a steep one for me. However, the project-based learning possibilities involving problem solving, data analysis, and technology integration encouraged me to step outside of my comfort zone.

Fortunately, it was not a journey I had to take without guidance. Vanderbilt professors, Janey Camp and Steve Beskeaf (also a USN alumni dad), generously provided their time and expertise so our 5th graders could dip their toes in GIS mapping. Janey and Steve’s passion in this field was inspiring. Their collaboration was instrumental in helping me design a project that would be engaging, yet developmentally age-appropriate for 5th graders. The objective of the project was to develop a core set of skills to get students thinking of maps they could design in the future.
Path Forward

- **Continue grassroots efforts to educate and train teachers**
  - **Empowering teachers**
    - Developing technical skills one teacher at a time
    - Confidence to “coach” students in inquiry-based learning using GT
    - Building a network of teachers using GIS
  - **Upcoming workshops**
    - Power of Data (POD) workshop in Nashville (June 2017)
    - Career and Technical Education (CTE) Institute (July 2017)
  - **IT Support**
    - Working with ESRI to get ArcGIS Desktop licenses on a case-by-case basis
    - Assisting with best practices for ArcGIS Online Org Account setup

- **Continue top-down administrative efforts**
  - **Working with TN Dept. of Education**
    - Identify career paths where GIS/GT matter (make the case)
    - Helping identify other courses where GIS/GT can be integrated
    - Still working to establish a state-wide ArcGIS Desktop license
  - **Seeking funding to expand dissemination, training, and evaluation efforts**
The use of geospatial technologies (GT), especially geographic information systems (GIS) and global positioning systems (GPS), are important tools used in today’s complex world to help solve problems. These tools can also be used to help educators, students, and their institutions answer personal and community questions with local to global implications. Efforts are underway to integrate GT into STEM curriculum in grades K-12 throughout Tennessee with researchers at Vanderbilt University leading the way. Dr. Janey Camp and colleagues Lindsey Longden-Vu and Kurt Butler (Tennessee Geographic Alliance) have begun training teachers on the use of GT for use in their STEM-focused classrooms to solve “real world” problems. Two introductory workshops for high school teachers have been held.

www.vanderbilt.edu/gised