How Can We Reap the Greatest Educational Benefits from GIS?

National Summit for GIS and K-12 Education
James Madison University

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1) Brief overview of some spatial thinking ideas

2) Ways to address spatial thinking with students

3) Making connections with both GIS and learning overall
Accurate mental visualization; Mental transformation of images.

The capacity to form mental imagery of the world—the large world of the aviator or navigator, or the more local world of the chess player or the surgeon—and to manipulate those mental images.

Howard Gardner, Multiple Intelligences
“Is Mental Rotation the Foundational Spatial Skill?”

Sorby et al., 2008, Michigan Technological University.
Visualization, abilities, aptitude
Accurate mental visualization; Mental transformation of images.

The capacity to form mental imagery of the world—the large world of the aviator or navigator, or the more local world of the chess player or the surgeon—and to manipulate those mental images.
Spatial thinking is...

an ability to visualize and interpret location, distance, direction, relationships, movement and change over space.

Sinton, 2009
Spatial thinking is a collection of cognitive skills based on:

- spatial concepts
- tools that we use to represent & understand spatial information and concepts
- ways we use those concepts and representations to reason and extract meaning about the natural and social world

### Spatial Concepts
- location, distance, direction
- orientation, rotation
- scale
- shape, form, pattern
- networks, associations
- regions, transitions
- diffusion, flow, migration

### Tools of Representation
- models (2D, 3D, 4D)
- maps (mental, concept, sketch, analog, digital)
- globes (traditional, digital)
- graphs, charts, figures
- principles of graphicacy

### Processes of Reasoning
- making decisions based on interpretations of spatial data
- recognizing concepts of space within and between disciplines
- deducing possible causal factors based on pattern interpretation
- predicting alternative scenarios based on modeled behaviors of spatial interactions
Thinking IN Space
Geography of our Life Spaces

- Navigating, wayfinding
- Daily activities: arranging, figuring out, assembling, packing
- Gaming, athletics

Thinking ABOUT Space
Geography of our Physical Spaces

- How the physical world works and is organized
- Observing patterns, clusters, outliers/anomalies
- Modeling

Thinking WITH Space
Geography of our Intellectual Spaces

- Geographic or spatial primitives
- Concept maps
- Spatial relationships among abstractions

“Spatializing” data
#1 Important Goal - We want to expand your awareness about the role of spatial thinking in your life and the world around you.

- Space vs. Place (Yi-Fu Tuan, *Space and Place: The Perspective of Experience*)

- Thinking In, With, and About Space

- Spatial Concepts diagram

- Proxemtics

- Day in the Life of a Spatial Thinker
  - categorizing spatial games
  - spatial language
  - videos, images
  - Find the spatial in….

- DEMs

- Google Earth, examples of spatial concepts
When I Was 10 Maps  (Edith Cobb, The Ecology of Imagination in Childhood)
Alexs When I was Ten Map

My School
This is the school I went to in 6th grade

Lynbrook High School
This was the local high school. We were afraid

Dev's House
This is my friend Dev's house. We would always

Miller Middle School
It's a middle school

Peter's House
This is Peter's house, another place we hung out

Cool Porsche House
This is the cool porsche house; it had a lot of cool

My House

No Go Zone
Last updated by alexsann on Sep 23.
sample of Spatial Language / Vocabulary

• tunnel vision
• narrow minded
• let’s step back to see the big picture
• on top of it all
• to top it all off
• the bottom fell out of the argument
• at the breaking point
• thinking outside of the box
• feeling on top of the world
• look at it from another angle
• Wednesday is “hump day”
• top tier
• Leftist policies
• running around in circles
• back of the pack
• under cover
• close the loop
• tread on thin ice
Spatial Games: Categories and Strategies

Wayfinding

Angles and Trajectories

Patterns

Areas of Influence / Auras

Rotations

Distances – Proximity and Adjacency

Combinations, Connections

Prior knowledge
Find the Spatial in...
teachspatial.org

"...spatial thinking is pervasive: it is vital across a wide range of domains of practical and scientific knowledge; yet it is underrecognized, undervalued, underappreciated, and therefore understudied."

National Research Council 2006 report: Learning to Think Spatially

teachspatial.org is a collaborative, interactive web site devoted to improving our understanding of how spatial thinking contributes to science and society, and to providing resources that promote applications of spatial concepts and spatial tools in teaching and learning. The site features three parts:

Part 1 enumerates and defines core concepts of spatial thinking, presented in the original words of authors from 18 source documents. Users of the site are invited to read the original publications to appreciate the contextual frameworks used by these authors. Please contribute to expanding the range of disciplines and specializations represented by suggesting additional source documents for inclusion.

Part 2 presents schemas that interpret, synthesize, and model aspects of spatial thinking that draw on and interact with selected concepts from part 1. Please submit your own schema and explanatory text; and please join others with commentary and questions for on-line discussion.

Part 3 will provide an archive of user-contributed resources for teaching and learning. Please share your pedagogic strategies, exercises, demonstrations, and course syllabi for use and consideration by others in their efforts to enhance spatial literacy.
What are the connections between GIS and spatial thinking?

Can GIS be used to help develop spatial thinking habits of mind?

What is the role of GIS as a support-system for learning in K-12?
<table>
<thead>
<tr>
<th>Spatial relations</th>
<th>Processes used in cognitive mapping and GIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abilities (skills) that recognize spatial distribution and spatial patterns</td>
<td>constructing gradients and surfaces</td>
</tr>
<tr>
<td>Identifying shapes</td>
<td>layering</td>
</tr>
<tr>
<td>Recalling and representing layouts</td>
<td>regionalizing</td>
</tr>
<tr>
<td>Connecting locations</td>
<td>decomposing</td>
</tr>
<tr>
<td>Associating and correlating spatially distributed phenomena</td>
<td>aggregating</td>
</tr>
<tr>
<td>Comprehending and using spatial hierarchies</td>
<td>correlating</td>
</tr>
<tr>
<td>Regionalizing</td>
<td>evaluating regularity or randomness</td>
</tr>
<tr>
<td>Comprehending distance decay and nearest neighbor effects in distributions (buffering)</td>
<td>associating</td>
</tr>
<tr>
<td>Wayfinding in real-world frames of reference</td>
<td>assessing similarity</td>
</tr>
<tr>
<td>Imagining maps from verbal descriptions</td>
<td>forming hierarchies</td>
</tr>
<tr>
<td>Sketch mapping</td>
<td>assessing proximity (requires knowing location)</td>
</tr>
<tr>
<td>Comparing maps</td>
<td>measuring distance</td>
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<tr>
<td>Overlaying and dissolving maps (windowing)</td>
<td>measuring direction</td>
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<tr>
<td></td>
<td>defining shapes</td>
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<tr>
<td></td>
<td>defining patterns</td>
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<td></td>
<td>determining cluster</td>
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<td>determining dispersion</td>
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</tbody>
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Seven Ideas to Help Begin to Link GIS with Spatial Thinking

• Identify when “pre-GIS” skills are necessary and have multiple and varied versions of materials that support that instruction.

• Do all you can to build up frames of reference – varying views and perspectives (2D and 3D) and recognizing the role of prior knowledge.

• When appropriate, attend to location, distance and direction.

• Don’t overlook the powerful role that vocabulary plays.

• Develop your own competence and confidence at pattern recognition and interpretation or analysis.

• Cultivate an awareness and appreciation of the uncertainty inherent within spatial data.

• Link maps and mapping to the broader picture of graphicacy.
DELUGE, Scott Wilkerson, Geology, DePauw University
Expand your Frames of Reference

“Is Mental Rotation the Foundational Spatial Skill?”

Sorby et al., 2008, Michigan Technological University

change your perspective
“It’s not something you would see until you actually saw it.”
GeoDa,
http://geodacenter.asu.edu/
Data and graph provided by Meg Stewart. Satellite imagery provided by Google Earth™ mapping service.
If assessment should be about what matters, what DOES matter in spatial thinking?

What matters is whether it’s applied or not.

• Is there evidence that spatial reasoning was used to reach a conclusion?

• Were spatial vocabulary words used – correctly – in a description?

• Has the student made a drawing, a diagram, a sketch, a figure, a chart that represents the information or situation?

• Is there understanding shown about how distance (or direction, or hierarchy, or being part of a region, or XX) is affecting the relationship between A, B and Z?
It is (almost definitely) impossible to single out GIS as a “treatment” variable in learning. There will always be too many confounding variables and factors.

the technology?

or

how do we learn (extract meaning, understand information) from maps?
Identified GIS Activities

- Geometric transformation (e.g., map scale and projection)
- Modifying map features (e.g., reshape, mirror image)
- Geoprocessing (e.g., merge, clip, intersect, union)
- 2D-3D visual transformation
- Map orientation
- Areal photo interpretation (oblique or vertical)
- Spatial measurement
- Data management (topology)
- Geocoding (georeferencing)
- Classifying spatial data (e.g., dot map, choropleth map)
- Spatial statistics (interpolation)
- Searching for patterns (e.g., distribution, network, hierarchy)
- Drawing (or tracing) spatial features
- Analyzing spatial data (e.g., map algebra, Boolean overlay operation, query builder, raster calculator)

Spatial Abilities

- Spatial Visualization
  Mentally manipulating, rotating, twisting, or inverting pictorially presented visual stimuli
- Spatial Orientation
  Remembering unconfused by the changing orientations in which a configuration may be presented
- Spatial Relations
  Recognizing spatial distributions and patterns
  Connecting locations
  Associating and correlating spatially distributed phenomena
  Comprehending and using spatial hierarchies
  Orienting to real-world frames of reference
  Imagining maps from verbal descriptions
  Sketching maps
  Comparing maps
  Overlaying and dissolving maps
Direction: The map below shows annual precipitation of Texas.

3. If you draw a graph showing change of Texas annual precipi
tion, the graph will be _______ (choose closest one).

(A) ![Graph A](image)

(B) ![Graph B](image)

(C) ![Graph C](image)

(D) ![Graph D](image)

(E) ![Graph E](image)

9. The following two images (3D and topographic map) show the same area. Find the
matching location of an arrow of 3D map on the topographic map (A~E).

A( ) B( ) C( ) D( ) E( )
Example of revised assessment question for an aquatic ecology class

**Original final exam question, prior to the extensive use of mapping/GIS:**
You have sampled water from Pine Hill Creek and monitored several indicators of water quality (pH, fecal coliform, BOD) over the last year. Discuss how the variables have changed over time and provide a rationale for why you believe this has occurred.

**Revised final exam question, after the extensive use of mapping/GIS:**
You have sampled water from Pine Hill Creek and monitored several indicators of water quality (pH, fecal coliform, BOD) over the last year. Draw a sketch of the Pine Hill watershed, including the locations of major land uses plus the flow pattern of ground and surface water. Mark your sampling locations and indicate where, how, and why the water quality indicators varied over the year.
THANKS!

Questions?

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