What is Spatial Thinking?

One of the three characterizations from NRC report on *Learning to Think Spatially*

3

- **Extracting spatial structures (encoding)**
  - Perception and/or creation of representation
  - Show elements and the spatial or conceptual relationships between elements with respect to reference frame

- **Performing spatial transformations**

- **Drawing functional inferences**
  - Complex spatial reasoning
  - Combining representations and transformations to evaluate or predict situations or events
What is Spatial Thinking?

- **Spatial representations:** properties of entities
  - Distinguishing figures from ground
  - Recognizing patterns
    - outline shapes
    - internal configurations
  - Evaluating size
  - Discerning texture
  - Recognizing color
  - Determining other attributes
What is Spatial Thinking?

- Spatial representations: relations between static entities
  - Determining location
  - Determining orientation
  - Assessing distance
  - Comparing size
  - Comparing color
  - Comparing shape
  - Comparing texture
  - Comparing location
  - Comparing other attributes
What is Spatial Thinking?

- Spatial representations: relations between dynamic entities
  - Direction of movement
  - Manner of motion
  - Speed or acceleration
  - Intersection or collision
What is Spatial Thinking?

• Transformation of representations
  – Changing perspective (reference frame)
  – Changing orientation (mental rotation)
  – Transforming shapes
  – Changing size
  – Moving wholes
  – Reconfiguring parts
  – Zooming in or out
  – Enacting
  – Panning
Technologies that Support Spatial Thinking

- Geographic Information Systems (GIS)
- Web-based tools for mapping and analyzing spatial data
  - TimeMap™ ([http://www.timemap.net/](http://www.timemap.net/))
    - Displays information on maps in animated time sequence
  - GeoDa® ([https://geoda.uiuc.edu](https://geoda.uiuc.edu))
    - Set of exploratory spatial data analysis software tools
    - Set of space-time analysis tools for regional data
- Web geo-browsers/virtual globes
- Global Positioning Systems (GPS)
- Statistical software, data management tools, graphics software
- downloadable data
TimeMap™

TimeMap™ of World Heritage Sites

Prepared by the University of Sydney's Archaeological Computing Laboratory for the UNESCO World Heritage Centre, Paris.
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GeoDa®

2006 SPACE workshop, Santa Barbara
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Virtual Globes

TerraExplorer

GeoFusion

World Wind

Google Earth

2006 SPACE workshop, Santa Barbara
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Assessment Strategies and Tools

- **Classroom Assessment Techniques (CATs)**
  - Prior knowledge survey
  - One-minute paper
  - Pro/con grid
  - Theory comparison
  - Self-confidence survey
  - Classroom response system

- **Portfolio Assessment**
  - Illustrates incremental development of knowledge and skills
  - Can include artifacts of map analysis, map design, or spatial decision-making activities
  - Can be realized as student course websites
### Spatial Organization Quiz

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<tbody>
<tr>
<td>1.** You’re more likely to get frostbite in January in:**</td>
<td>6. <strong>You’ll probably take home more of your paycheck if you live and work in:</strong></td>
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<td></td>
<td>a) Milwaukee, WI</td>
<td>a) Massachusetts</td>
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<td>b) Miami, FL</td>
<td>b) Tennessee</td>
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<td>2. <strong>To attend an NBA basketball game, you should go to:</strong></td>
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<td>7. <strong>You’re more likely to hear Spanish being spoken by residents of:</strong></td>
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<td>a) Chicago, IL</td>
<td>a) New York City, NY</td>
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<td>b) Boise, ID</td>
<td>b) São Paulo, Brazil</td>
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<td>3. <strong>You’re more likely to hear country music on your car radio while driving though:</strong></td>
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<td>8. <strong>Your chances of being murdered are greater if you live in:</strong></td>
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<td></td>
<td>a) Arkansas</td>
<td>a) New York City, NY</td>
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<td>b) Connecticut</td>
<td>b) Tampa, FL</td>
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<td>4. <strong>You’re more likely to be bitten by a shark in:</strong></td>
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<td>9. <strong>You’re more likely to find a Vietnamese restaurant in:</strong></td>
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<td>a) The Gulf of Mexico</td>
<td>a) Seattle, WA</td>
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<td>b) Lake Erie</td>
<td>b) Minneapolis, MN</td>
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<td>5. <strong>An average 4-bedroom ranch home would typically cost more in:</strong></td>
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<td>10. <strong>You’re more likely to encounter a senior citizen (person aged 65 or older) if you live in:</strong></td>
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<td>a) Mobile, AL</td>
<td>a) Arizona</td>
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<td></td>
<td>b) Los Angeles, CA</td>
<td>b) Pennsylvania</td>
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</table>

*from: Oldakowski, 2001*
Spatial Organization Quiz

8. Your chances of being murdered are greater if you live in:
   a) New York City, NY
   b) Tampa, FL

Many students will answer NYC to Question 8.
   – Incorrect rationale: NYC is larger, so will have more murders
   – More sophisticated spatial and statistical thinking: the chance of being murdered is related to the murder rate (murders per 100,000 people), and the murder rate is higher in Tampa.

10. You’re more likely to encounter a senior citizen (person aged 65 or older) if you live in:
    a) Arizona
    b) Pennsylvania

Many students will answer Arizona to Question 10.
   – Incorrect rationale: many people move to Arizona when they retire
   – More sophisticated spatial and statistical thinking: Pennsylvania has higher percentage of persons aged 65 and over due to outmigration of younger residents and a lower birth rate.

from: Oldakowski, 2001
Spatial Organization Quiz

- Following quiz, students can be presented with a set of choropleth (or proportional symbol or dot density) maps of the variables mentioned in the quiz. These maps should be unlabeled.

- Students work together to try to identify which variables are represented on each map.

- Students work to identify which maps show variables that have similar patterns. Variables can be identified before or after this step.

- Students can use these labeled maps to score their own quizzes. For questions that they initially answered incorrectly, they can write or talk about the rationale behind their original answer, and propose an explanation for the answer they discovered by looking at the maps.

- Students choose an additional variable and create a map based on this new variable. Students compare maps and try to identify variables and patterns on new maps.

adapted from: Oldakowski, 2001
Learning through Problem Solving

- Guided problem-solving activities
  - Classic example from Jerome Bruner
    - Presented students with map of region that showed only rivers, lakes, and natural resources
    - Students decided where major cities are likely to be located
  - The spatial problem-solving approach can be adapted to a wide variety of contexts through selection of appropriate datasets and tasks.
Examples of guided problem-solving activities

- Students can be given a thematic map (e.g., choropleth or proportional symbol) and be asked to make lists of variables the symbols could represent. Students could accompany their lists of possible variables with descriptions of their rationale.

- Students could make their own thematic map and then describe the patterns they observe and why these patterns support or contradict hypotheses developed prior to map creation.

- Each student in a class or group makes a choropleth, dot density, or proportional symbol map to represent distribution of a different variable but within the same geographic region. Students compare their maps to the others made by their group members, and look for correlations between variables.
Learning through Problem Solving

- Examples of guided problem-solving activities

  - Students view a photo of a person, (e.g., a homeless person), and are asked to discuss the reasons why this person might be homeless. Following a discussion of why an American homeless person may be homeless, students could also view a photo of a homeless African and once again discuss the reasons for homelessness. The instructor may ask leading questions to focus the discussion on spatial variables, and may highlight differences in the nature of the variables used to explain American and African homelessness.*

  - Students may be asked to identify places based on photos, describing the rationale behind their ideas.*

  - Students use satellite imagery of a region to identify patterns in the landscape

  - Students use ‘layers’ of geographic data to make a decision

  - Students imagine that it is the year 4006 AD. They draw an imaginary site map for ‘___’, and write a description of what they would expect to find in an excavation of the area, and why

* ideas contributed by Steve Graves and Claudia Scholz
Coaching Strategies for Problem-based Learning

• Coaching Student Conceptualization of Case Issues
  – Structure the discussion by giving students an initial role to play or a position to take in the discussion.
    • Avoids feeling of being ‘exposed’
    • Provides parameters to guide formation of initial response
    • Ensures that a variety of viewpoints will be expressed
  – Begin the discussion with a structure, but avoid rigid adherence to that structure.
    • Sets up discussion, and can keep dialog going
    • Discussion-chain approach: make statement, ask open-ended question, present ground rules for subsequent discussion

• Coaching Student Consideration of Implications of Solutions
  – Ask specific questions and limit the number that you ask at one time.
    • One at a time:
      – Identify problem
      – Suggest solution
      – Describe possible impacts of solution
    • If you had to do it over again, what would you do differently?
    • Now that you’re in this pickle, what will you do next?
  – Look for opportunities to join the discussion, but participate carefully.
    • Instructor input can easily be viewed as “answer”
    • Model expert responses and call attention to ‘playing the devil’s advocate’

from: Stepich, et al., 2001
Spatial Thinking Inventory

Appendix

Spatial Thinking Inventory

<table>
<thead>
<tr>
<th>Concepts</th>
<th>yes</th>
<th>no</th>
<th>or</th>
<th>none</th>
<th>basic</th>
<th>advanced</th>
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<td>symmetry</td>
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<td>isomorphism</td>
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<td>reflection</td>
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<td>rotation</td>
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<td>class or category</td>
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<td>sequence/order</td>
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<td>connection/linkage</td>
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<td>scale (small vs. large)</td>
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<td>distance decay</td>
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<td>discrete vs. continuous (point vs. field)</td>
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<td>relations among units of measurement (e.g., kilometer vs. mile)</td>
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<td>basis of coordinate systems</td>
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Learner demonstrates understanding of/ability to:

- Concepts
- Thought processes and problem-solving strategies
- Representation
- Use of technology
References

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- Google Earth image: http://earth.google.com/coverage/saudiarabia_lg.jpg
- Google Earth image: http://earth.google.com/coverage/northamerica_lg.jpg
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- Satellite imagery: http://www.gisdevelopment.net/application/archaeology/general/images/ps401.jpg
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- Happiness map: http://www.le.ac.uk/pc/aw57/world/sample.html
- Spatial thinking inventory: http://www.geog.ucsb.edu/~rebich/SAA2006paper.pdf