Learning and Assessing Spatial Thinking

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Spatial Analysis in the Social Science Curriculum: Enhancing Undergraduate Learning
A Few Questions

• What is the purpose of student assessment?

• How do you choose an assessment approach?

• How do you know that your assessment approach has construct validity?
A Brief History of Learning Theory

Three dominant theories:

- **Behaviorism** (begins with Aristotle)
  - Focus on measurable behavior
  - Stimulus and reinforcement used to produce desired behavior

- **Cognitivism** (becomes strong in 1950s, influence on instructional design begins in 1970s)
  - Focus on mental representation and schema
  - Information processing model

- **Constructivism** (appears 1930s, associated with Piaget)
  - Learner has active role construction of meaning
  - Importance of knowledge structure and prior knowledge
  - Role for social negotiation of meaning
A Brief History of Learning Theory

Associated pedagogical approaches:

- **Behaviorism**
  - Taxonomic analysis: task broken down into specific measurable tasks
  - Drill and practice
    - Mastery learning
    - Programmed instruction
    - Computer-assisted instruction (CAI)

- **Cognitivism**
  - Enhanced taxonomic analysis that takes into account mental representation
  - Build from simple to complex schema
    - Advance organizers
    - Mnemonic devices
    - Metaphors
    - Chunking
    - Sequencing
  - Algorithmic approaches
A Brief History of Learning Theory

Associated pedagogical approaches:

- **Constructivism**
  - Open-ended learning experience
    - Methods and results not necessarily the same for each learner
  - Multiple representations of reality
    - Natural complexity
  - Authentic tasks – “situated learning”
  - Case-based learning (see Stepich et al.)
  - Reflective practice
  - Collaborative construction of knowledge through social negotiation
  - Models for learners based on accomplished novices rather than experts
  - Instructor as coach or mentor – “cognitive apprenticeship”
  - Hypertext and hypermedia
    - Requires “anchoring”
Choosing an Instructional Approach

- Approach should be based on type of learning necessary or desired

- Most undergraduate learning situations best satisfied through a **combination of cognitive and constructive approaches**
  - **Cognitive:**
    - Classifications, schematic organization, analogical reasoning, algorithmic problem solving
  - **Constructive:**
    - Heuristic problem solving, ill-defined problem-solving, selection and monitoring of cognitive strategies
Choosing an Instructional Approach

Comparison of the associated instructional strategies of the behavioral, cognitive, and constructivist viewpoints based on the learner's level of task knowledge and the level of cognitive processing required by the task.

Adapted from Ertmer & Newby: Behaviorism, Cognitivism, Constructivism: Comparing Critical Features from an Instructional Design Perspective
Problem-Based Learning

- “problem-first learning”
- Often involves interdisciplinary collaboration
- Often instructional method of choice in applied fields where the knowledge base is rapidly changing
  - Medicine
  - Technical disciplines
- Many benefits reported in literature (see Pawson et al.)
- Potential risks
  - May be difficulty producing tangible results that support claims for advantages
  - Group dynamics
    - Uneven distribution of work and responsibility
    - Students with less background knowledge and skills may fall further behind when mature students take over
  - Student lack of familiarity with (and resistance to) this learning style
  - Students may prefer more structure
  - Focus may be on “doing”, to the excluding of thinking, reflection, and accommodation
Problem-Based Learning

- Starting points for success with PBL:
  - Problem scenarios that are multidimensional and complex enough to require teamwork
    - On the other hand, focused enough that they can be finished in the time available
  - PBL experience should begin at or near beginning of term
  - Instructor-assigned permanent work groups
    - Roles may also be assigned: leader, recorder, skeptic, etc.
  - Clear guidelines for conduct and expectations
  - Probing questions that help guide student inquiry
  - Clear product or outcome
  - Authentic assessment
  - Clearly established evaluation criteria that are understood by the students
  - Accountability
    - Individual and group evaluations
  - Self- and peer-assessment
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

1. **You’re more likely to get frostbite in January in:**
   - a) Milwaukee, WI
   - b) Miami, FL

2. **To attend an NBA basketball game, you should go to:**
   - a) Chicago, IL
   - b) Biose, ID

3. **You’re more likely to hear country music on your car radio while driving through:**
   - a) Arkansas
   - b) Connecticut

4. **You’re more likely to be bitten by a shark in:**
   - a) The Gulf of Mexico
   - b) Lake Erie

5. **An average 4-bedroom ranch home would typically cost more in:**
   - a) Mobile, AL
   - b) Los Angeles, CA

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1. **You’ll probably take home more of your paycheck if you live and work in:**
   - a) Massachusetts
   - b) Tennessee

2. **You’re more likely to hear Spanish being spoken by residents of:**
   - a) New York City, NY
   - b) São Paulo, Brazil

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

4. **You’re more likely to find a Vietnamese restaurant in:**
   - a) Seattle, WA
   - b) Minneapolis, MN

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

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*from: Oldakowski, 2001*
1. 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.

1. 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.
Learning through Problem Solving

- 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.*

* ideas contributed by Steve Graves and Claudia Scholz
Learning through Problem Solving

- Examples of guided problem-solving activities
  - 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
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.
  – Begin the discussion with a structure, but avoid rigid adherence to that structure.

• Coaching Student Consideration of Implications of Solutions
  – Ask specific questions and limit the number that you ask at one time.
  – Look for opportunities to join the discussion, but participate carefully.

from: Stepich, et al., 2001
Technologies that Support Spatial Thinking

- Geographic Information Systems (GIS)
- Web-based tools for mapping and analyzing spatial data
  - TimeMap™ (http://www.timemap.net/)
    - Displays information on maps in animated time sequence
  - GeoDa® (https://geoda.uiuc.edu)
    - Set of exploratory spatial data analysis software tools
  - STARS© (http://stars-py.sourceforge.net/)
    - Set of space-time analysis tools for regional data
- Web geo-browsers/virtual globes
  - http://www.csiss.org/SPACE/resources/virtual
- Global Positioning Systems (GPS)
- Statistical software, data management tools, graphics software
- Downloadable data
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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### Spatial Thinking Inventory

**Appendix**

**Spatial Thinking Inventory**

<table>
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<tr>
<th>Concepts</th>
<th>yes</th>
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</tbody>
</table>

- **Concepts**
- **Thought processes and problem-solving strategies**
- **Representation**
- **Use of technology**
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Image Sources

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