A spatial literacy initiative for undergraduate education at UCSB

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ThinkSpatial Brown-bag forum
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Applying Concepts of Spatial Thinking to Describe, Analyze, Understand & Predict, & to Create, Plan & Design

Space-time Patterns & Processes
A Natural / Structural View on the Space of Knowledge

Goodchild & Janelle
An Empirical / Pragmatic View on the Space of Knowledge

- Discipline Cores
- Organizations and Institutions
- Individual Career Paths

Goodchild & Janelle
Spatial thinking is transformative

- **Value** for daily living and for problem solving in society and science
- Transcends **disciplinary boundaries**
- Unites **quantitative and qualitative thinking**
- Allies with **multi-media graphic display and communication** of information
- A domain of continuing significant **knowledge development**
- Not necessarily easily and intuitively acquired
Contrasting but Complementary Perspectives

**SILC**

**Focus:**
- spatial cognition
- understanding spatial learning
- Improve K-12 education practices to foster spatial skills & spatial functioning

**Methodology:**
- Identify basic elements of spatial thinking
- Controlled experiments to measure understanding, learning, & skill development

**spatial@ucsb**

**Focus:**
- Geospatial concepts in social, environmental, & behavioral sciences
- Curriculum development for undergraduate education

**Methodology:**
- Identify fundamental geospatial concepts
- Context dependent applications (re: disciplines, theory, problems, policies)
- Tools of spatial analysis (e.g., GIS)
Context Dependence across Disciplines

- **Disciplines claim uniqueness** of theories, problems, and areas of application; yet also **share** fundamental objectives and methodologies.

- **Sciences** seek identification and understanding of patterns and processes about the physical world and its phenomena.

- **Social sciences** focus on interdependence among people & groups, grounded in place, space, & time and the need to understand patterns & processes of human behavior.

- **Engineering and design sciences** focus on problem solving and product development that frequently entails the (re) arrangement of spatial entities and the consequences.

- **Humanities** focus on human creativity and aesthetic renderings (stories, visualizations, sounds) that often affirm affinity to sense of place and regional identity, use spatial metaphor, and rely on spatialized languages for communication.
Geo-spatial Concepts for Spatial Reasoning

- **Location** – Understanding formal & informal methods of specifying “where”
- **Distance** – The ability to reason from knowledge of relative position
- **Network** – Understanding the importance of connections
- **Neighborhood & Region** – Drawing inferences from spatial context
- **Overlays** – Inferring spatial associations by comparing mapped variables by locations
- **Scale** – Understanding spatial scale & its significance
- **Spatial Heterogeneity** – The implications of spatial variability
- **Spatial Dependence** – Understanding relationships across space (Tobler’s First Law)
- **Objects & Fields** – Viewing phenomena as continuous in space-time or as discrete
1. Location

- Defining and measuring location
  - the impossibility of exact measurement
- From infinitesimal point to extended area
- Place
  - how many places are there in the U.S.?
  - what is the most populous city in the world?
- Location as context
- Location as common key
- It is important to know *where* events occur
2. Distance, direction

- Measurement
  - plane, globe
  - buffers

- Distance decay
  - decline of interaction with distance
  - cost, time impediments
  - footprints of human behavior
from Lance Waller, Emory University


3. Neighborhood/region/territory

- The context of individuals
  - action space
- Homogeneous areas
- The reporting zone containing the individual
  - arbitrarily imposed on a continuous Earth
- The ecological fallacy
  - the modifiable areal unit problem
- Competition for space
  - trade areas, bird territories
  - functional regions
Areal Interpolation Example: Population Density in California

Legend
Population Density [P/sqm]
- 1.650 - 4.320
- 4.321 - 11.920
- 11.921 - 28.030
- 28.031 - 59.820
- 59.821 - 136.910
- 136.911 - 304.160
- 304.161 - 679.340
- 679.341 - 1989.020
- 1989.021 - 3663.540
- 3663.541 - 16862.960

Original dataset
Population density by county

After areal interpolation
Population density 3-digit zip code regions
4. Scale

- Level of detail
  - the inevitability of generalization

- Extent

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<th>Length of a Coastline</th>
<th>Source</th>
</tr>
</thead>
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<td><a href="http://earthtrends.wri.org/text/coastal-marine/variable-61.html">Earth Trends</a></td>
</tr>
</tbody>
</table>

- Scale is always important
  - many properties cannot be defined independently of scale
    - length of a coastline
    - slope of a topographic surface
    - land use class
Unique to spatial thinking?

- Analogs of spatial scale in other domains
- Observed properties of spatial data
  - what makes spatial special?
5. Spatial dependence

• “All things are related, but nearby things are more related than distant things”
  – “nearby things are more similar than distant things”
  – geostatistics, Moran statistic
  – the most important property of any spatially distributed phenomenon

• Challenges the normal assumptions of statistical tests
  – independent, randomly chosen samples
6. Spatial heterogeneity

• TFL describes a second-order effect
  – properties of places taken two at a time
  – a law of spatial dependence
  – is there a law of places taken one at a time?

• Spatial heterogeneity
  – non-stationarity
  – uncontrolled variance
Practical implications

• A state is not a sample of the nation
  – a country is not a sample of the world
• Results of any analysis will depend explicitly on spatial bounds
• Classification schemes will differ when devised by local jurisdictions
• Figures of the Earth will differ when devised by local surveying agencies
• Global standards will always compete with local standards
• Strong argument for place-based analysis, local statistics, geographically weighted regression
Integrating Concepts for Spatio-temporal Reasoning

Scientific and civic applications generally integrate multiple spatial concepts simultaneously to engage general types of spatial reasoning to:

• (1) detect changes in the uses of space(s)
• (2) measure arrangements and clustering
• (3) document patterns over time to infer process
• (4) study flows as indicators of spatio-temporal interactions
• (5) assess space-time associations to test hypotheses
Initiatives by spatial@ucsb

• Workshop on spatial curriculum
  (hosted by University of Redlands, June 2008):
  – Wiki support site for teachers
  – White paper on spatial thinking in the general undergraduate curriculum

• Specialist meeting on Spatial Concepts in GIS and Design (Dec 2008)

• TeachSpatial.org (coming soon)
What can be accomplished at UCSB?

- Academic **Major** (degree program) in spatial thinking
- Multi-disciplinary **Minor** in spatial thinking
- **Emphasis** in spatial thinking within existing degree programs
- **Specialization** in spatial thinking within existing degree programs
- **Independent Studies** (98/99; 198/199)
- Introduction to **spatial thinking as part of existing courses**
- **General Education Course**
- **Freshman Seminar** (Interdisciplinary 94)
- **Multi-discipline Graduate course** (NSF Spatial thinking IGERT ?)
Questions (from the Redlands workshop)

- Why is there interest in a general course on spatial thinking?
- Can we define “spatial literacy”?
- Who (what disciplines) should teach a course like this?
- Objectives?
- What spatial thinking concepts would be covered?
- How much should this course be guided by cognitive science?
- What might the syllabus look like?
- What online resources support development and delivery?
- What are valid and interesting forms of assessment?
Questions (from the Redlands workshop) 2

- Is there a **role within the general education framework** for a course on spatial thinking?
- Are there **institutional impediments**?
- Who are the **other major players** with interest in spatial thinking?
- Who might like to be **aware** of our activities?
- What types of **funding** could support this initiative?
- **Other unanswered questions**?
- **Next steps**?
Open Discussion
Thank You

Please check [www.spatial.ucsb.edu](http://www.spatial.ucsb.edu) for information on applications of spatial thinking