Professional Development to Improve Spatial Thinking of Earth Science Teachers & Students

Overview of Project

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Teachers’ Orientation
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From 1941 Earth Science Regents exam
Spatial thinking is thinking that finds meaning in the
• shape,
• size,
• orientation,
• location,
• direction, or
• trajectory

….of objects, processes, or phenomena,

….or the relative positions in space of multiple objects, processes, or phenomena.
Spatial Thinking in Geoscience

• Describing the shapes of natural objects, rigorously and unambiguously.

• Categorizing objects by their shape.

✓ Ascribing meaning to the shape of a natural object.

• Recognizing a shape or pattern amid a cluttered noisy background.

✓ Visualizing a 3-D object or structure or process by examining observations collected in one or two dimensions.

• Describing the position and orientation of objects in the real world relative to a coordinate system anchored to the Earth.

Spatial Thinking in Geoscience

• Recalling locations of previously observed geological phenomena.

✓ Mentally manipulating a volume by folding, faulting, and eroding.

• Envisioning the motion of objects or materials through space in three dimensions.

• Making and interpreting spatial representations (including maps).

• Using spatial thinking to think about time.

• Using spatial thinking to think about non-spatial properties.

Ascribing meaning to the shape of a natural object.


Mylonite. Note fine grain size and strong foliation probably caused by intense shearing.

Source: http://www.glg.ed.ac.uk/cgi-bin-2/config2-spvft

Source: http://www.geolab.unc.edu/Petunia/IgMetAtlas/meta-micro/mylonite.X.html
Mentally manipulating a volume by folding, faulting, and eroding.

Visualizing a 3-D object or structure or process by examining observations collected in one or two dimensions.
Spatial cognition is a well-developed field of cognitive and learning science research.

Downs and Liben (1991) studied college students’ ability to anticipate the form of a shadow cast by a shape rotated to various angles.

Spatial tasks can be quite difficult.

Performance on spatial tasks shows wide person to person variation.

Students who struggle with typical verbally-demanding academic tasks may excel on spatially-demanding tasks.

http://www.ldeo.columbia.edu/~kastens/curriculum/maptutorial/01_About_Spatial_Thinking/09a_SpatialVsVerbal.html
Spatial thinking can be improved through instruction and practice.

Computer-supported instructional activities to foster spatial thinking in Earth Sciences, developed by Steve Reynolds

http://www.ldeo.columbia.edu/~kastens/curriculum/maptutorial/04_3-D_Phenomena/3-D_05a.html
The Earth Science Regents exam is full of questions that can be answered by using spatial thinking.

63 The diagram below shows the position of sunrise along the horizon for a period of time from September 10 until December 21, as seen by an observer near Binghamton, New York.

State one reason why the position of sunrise changes during this time period.
Base your answers to questions 76 through 78 on the map and the stream data table below. The map represents a stream flowing into a lake. An arrow shows the direction of streamflow. Points A and B are locations at the edge of the stream. Line AB is a reference line across the stream surface. Line CD is a reference line along the lake bottom from the mouth of the stream into the lake. The data table gives the depth of the water and distance from point A, in feet, along line AB.

<table>
<thead>
<tr>
<th>Point A</th>
<th>Stream Data Table</th>
<th>Point B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance from Point A (ft)</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Depth of Water (ft)</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

76…construct profile.  77….explain profile (asymmetry)…. 78 …sediments include clay, pebbles, sand and silt….most likely order of deposition along C to D …
“You get what you test for.”

But in this case, we hypothesize:

• that the test is actually testing for something useful that many teachers are not attuned to;
• that some students (and some teachers?) fare consistently poorly on the spatially-demanding items;
• that performance (and happiness) of those teachers and students could be improved through professional development targeted towards spatial thinking;
• that spatial thinking is “low-hanging” fruit in science education reform.
Pilot project proposed to NSF/GeoEd (Kastens & Passow)

• Piggyback onto existing Earth2Class teacher professional development program (2011-2012 school year)

• Analyze past exams for spatially-demanding questions; categorize according to spatial thinking process and difficulty

• Develop spatial thinking lessons based on Sorby, Piburn, Clausen-May, Kali, etc., adapted to Regents-like questions

• Selected Earth2Class teachers critique, adapt, provide practitioners’ proven strategies, etc.

• Revise to merge insights from research on learning literature with PCK from experienced master teachers

• Be ready to infuse spatial thinking into regional and national data-driven professional development efforts.
Learning Goals for “Spatial Thinking in Earth Science”

• Teachers recognize that spatial thinking is pervasive in Earth Sciences

• Teachers understand that performance on spatial tasks:
  • differs widely among individuals
  • does not necessarily correlate with other academic strengths,
  • can be improved with instruction and practice.

• Teachers will be able to design, select, and effectively use student activities that foster spatial thinking in Earth Sciences.
What we need from you

• Attend nine sessions, barring compelling conflicts

• During the Saturday sessions
  • Critique activities, lessons and assessments
  • Suggest and co-develop additional learning resources
  • Provide insights from about student challenges in spatial thinking

• In your school:
  • Incorporate program resources into your instruction
  • Provide observations about how the materials worked
  • Bring illustrative student products for discussion (de-identified)

• Participate in item analysis of Earth Science Regents exam results