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

“Finding the Spatial” in Earth Science Regents Exams

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Teachers’ Orientation
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From 1941 Earth Science Regents exam
“Finding the Spatial” in Earth Science Regents Exams

• Began with a holistic definition: “… thinking that finds meaning in the shape, size, orientation, location, direction or trajectory…. “

• Saturday work session with teachers (Nov. 2010): what did they think was spatial in the Earth Science Regents?

• Initial classification into spatial/non-spatial

• Gradual articulation of sub-categories:
  • Spatial concepts
  • Spatial representations
  • Spatial skills

• Goal is to code 11 exams.
Spatial Concepts

- Position
- Configuration
- Distance
- Direction
- Motion
- Speed
- Trajectory
- Angle

- Size
- Volume
- Area
- Shape/morphology
- Texture
- Gradient
- Global interconnection
- Cycle
The map below shows the names and ages of different bedrock formations in North America. The bedrock ages are shown in billions of years.

The ages shown on the map suggest that the
(1) oldest bedrock is located in the Churchill formation
(2) youngest bedrock is located in the Wyoming formation
(3) younger bedrock has been added to the east and west coasts of the continent
(4) age of bedrock increases from west to east across the continent
Shape/Morphology (SC-Sh)

Base your answers to questions 42 through 44 on the cross section below, which shows the bedrock of a portion of the Helderberg Escarpment, located in Thacher State Park near Albany, New York. The rock formations are identified by name.

42 Which formations appear to be the most resistant to weathering?
(1) Esopus and Oriskany
(2) Onondaga and Coeymans
(3) Schoharie, and Marcellus and Hamilton
(4) New Scotland, and Schenectady and Indian Ladder beds
Texture (SC-Tx)

6. Which type of land surface will most likely absorb the greatest amount of incoming solar radiation?
   (1) rough, dark-colored surface
   (2) rough, light-colored surface
   (3) smooth, dark-colored surface
   (4) smooth, light-colored surface

14. Sediments found in glacial moraines are best described as
   (1) sorted and layered
   (2) sorted and not layered
   (3) unsorted and layered
   (4) unsorted and not layered

Texture causes or influences an earth phenomena (albedo)

Texture is caused by an earth process (glacial deposition)
Spatial Representations

- Map
- Cross-section/ profile
- Block diagram
- Photograph
- Graph of Y versus Distance
- Solar system representation
- Other
44 At which location would the Mississippi River’s discharge most likely be the greatest?

(1) A  
(2) B  
(3) C  
(4) D
The photograph below shows a large boulder of metamorphic rock in a field in the Allegheny Plateau region of New York State.

The boulder was most likely moved to this location by

1. glacial ice
2. prevailing wind
3. streamflow
4. volcanic action
Spatial Skills

- Perspective taking
- Mental animation
- Sequencing
- Describing spatial phenomena
- Representational Correspondence
- Visual penetrative ability
The diagram below shows the position of the Sun, the Moon, and Earth during a solar eclipse. The full shadow (umbra) and partial shadow (penumbra) of the Moon and Earth are shown.

Which diagram best represents the appearance of the Sun and the Moon to an observer located within the umbra of the Moon's shadow on Earth's surface?
Mental animation (SS-MA)

2 A camera was placed in an open field and pointed toward the northern sky. The lens of the camera was left open for a certain amount of time. The result is shown in the photograph below. The angle of the arc through which two of the stars appeared to move during this time exposure is shown.

How many hours was the lens left open to produce the photograph?

(1) 12
(2) 2
(3) 6
(4) 4
Representational Correspondence (SS-RC)

17 In which New York State landscape region have fossilized footprints of *Coelophysis* dinosaurs been found in the surface bedrock?

(1) Allegheny Plateau  
(2) Tug Hill Plateau  
(3) Hudson-Mohawk Lowlands  
(4) Newark Lowlands

Geologic History -> Bedrock map -> Landscape regions map
Criteria for Exclusion

• Spatial concept is mentioned but is not used in solving the problem and offers no added value for teaching.

• There is a spatial representation, but the task is purely look-up, no thinking.

• The dimensions of the paper are used to express a non-spatial attribute ("spatialization").

• There is a deep way to think about the question spatially, but that is beyond HS teaching/learning.
Spatial attribute mentioned, but no thinking about space/spatial is required.

26. Which pie graph correctly shows the percentage of elements by volume in Earth’s troposphere?
Use of spatial representation is a simple look-up

Base your answers to questions 53 through 57 on the map below, which shows the generalized surface bedrock geology of Iceland, an island located on the Mid-Atlantic Ridge. Points A, B, C, and D are locations on surface bedrock which is igneous in origin. Glaciers cover some surface bedrock.

54 According to the map, during which geologic era did the surface bedrock at location D form? [1]
Density = Mass/volume

what controls the volume of a rock? > relationships among pressure, temperature and volume > fractional melting > what controls the partitioning of rocks into continents and oceans? > low density makes continents stand higher > isostasy

18. The basaltic bedrock of the oceanic crust is classified as

1. felsic, with a density of 2.7 g/cm³
2. felsic, with a density of 3.0 g/cm³
3. mafic, with a density of 2.7 g/cm³
4. mafic, with a density of 3.0 g/cm³
Observations to date

• Spatial thinking is abundant in Earth Science Regents:
  ▪ ~65% of items are spatial by our criteria
  ▪ similar % in multiple choice and constructed response
  ▪ not final figures!

• A wide range of spatial concepts, spatial representations, and spatial skills are being assessed.

• Earth Science Reference Tables enable more challenging questions using spatial representations.