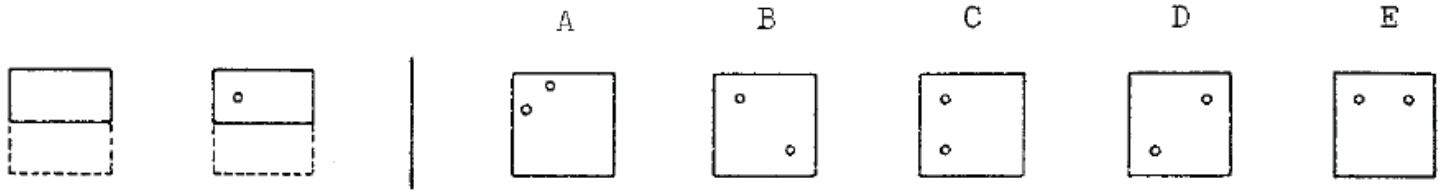
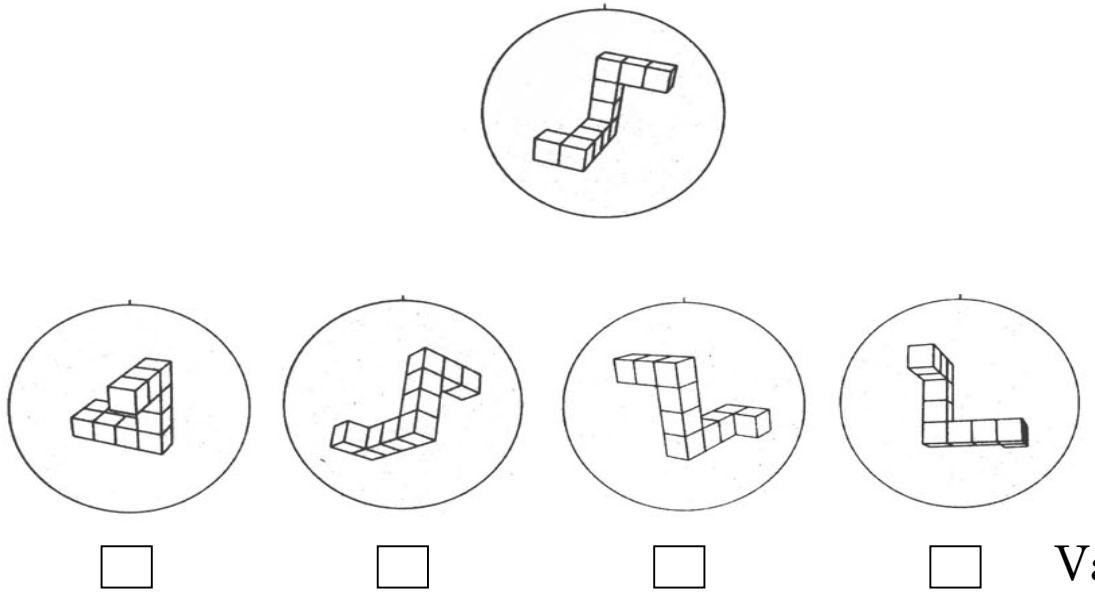
Opportunities to promote visuospatial skills development and geoscience learning in the Next Generation Science Standards (NGSS)

Nicole D. LaDue, Northern Illinois University, DeKalb, Illinois

What are visuospatial skills?



Ekstrom et al. 1976



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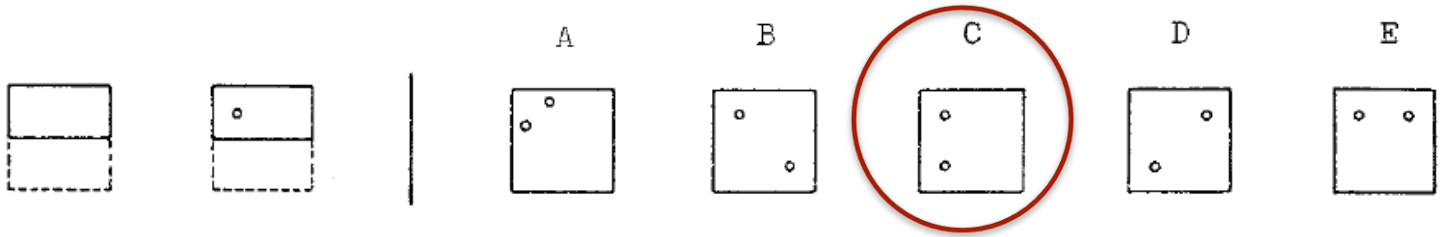

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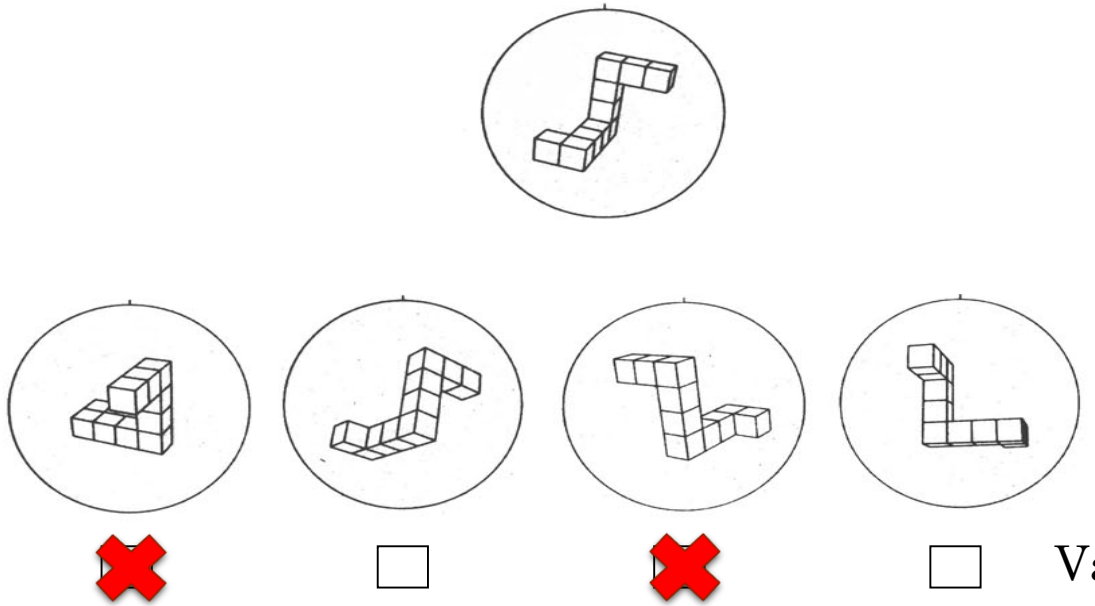

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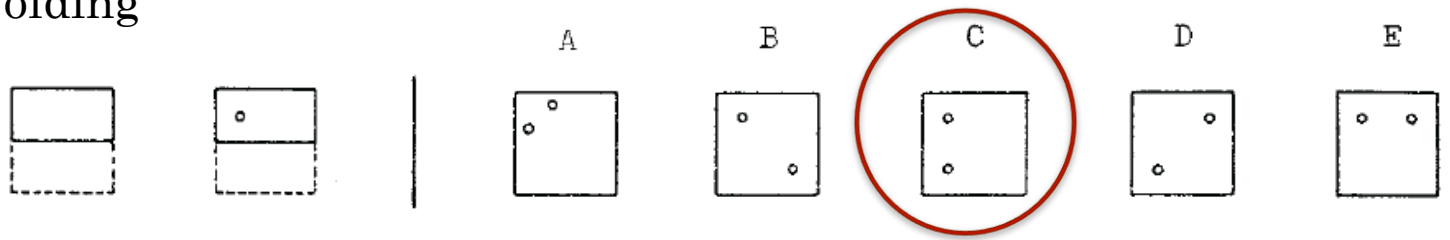
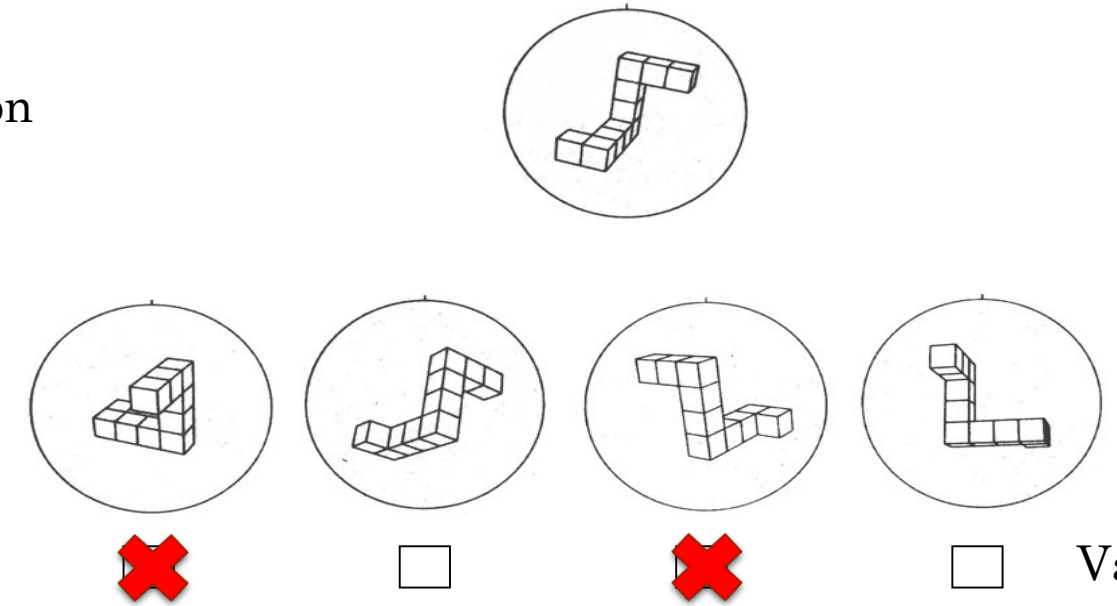
What are visuospatial skills?

Paper Folding



Ekstrom et al. 1976

Mental Rotation



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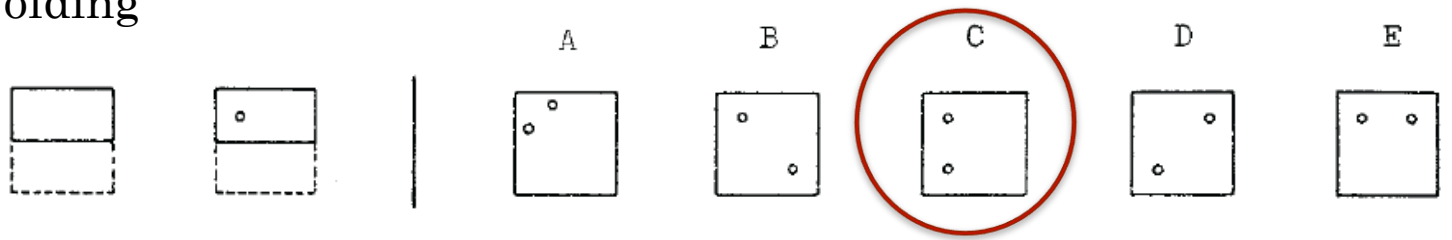
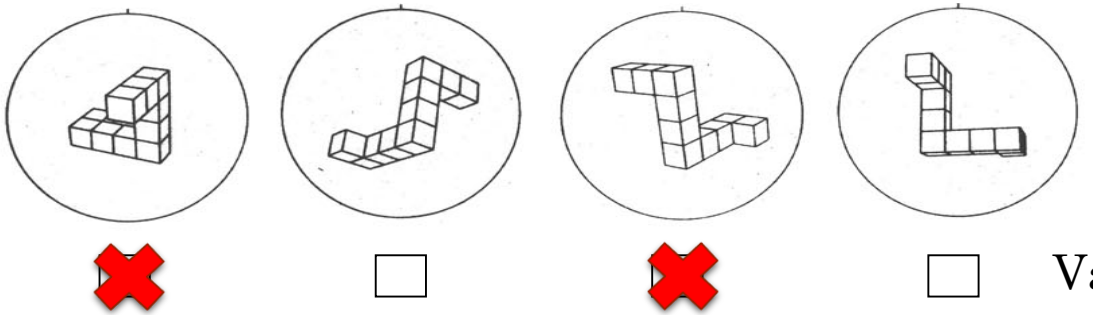


Ekstrom et al. 1976

Domain General: Skills and abilities that may transfer to a variety of settings



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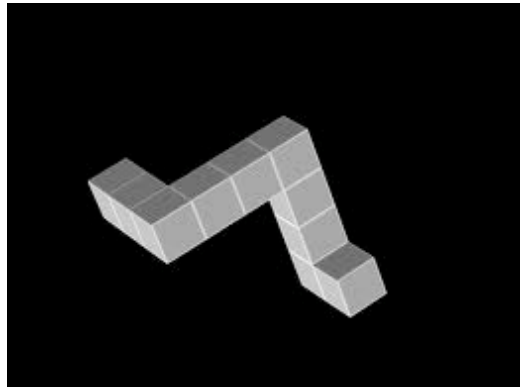
What are visuospatial skills?

Domain General Spatial Skills



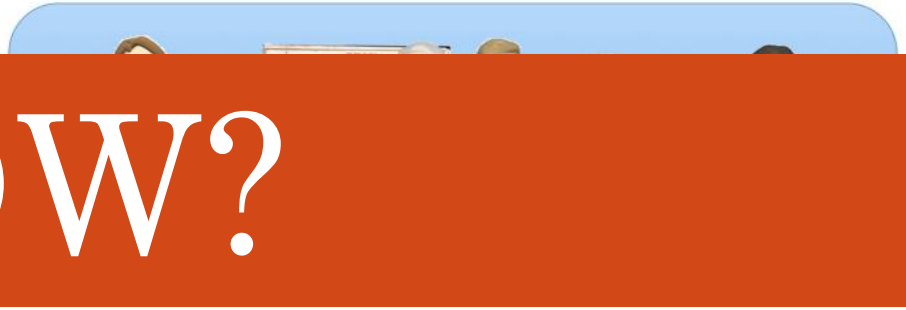
STEM Careers

Shea et al., 2001; Wai et al., 2009

What are visuospatial skills?

Domain General Spatial Skills

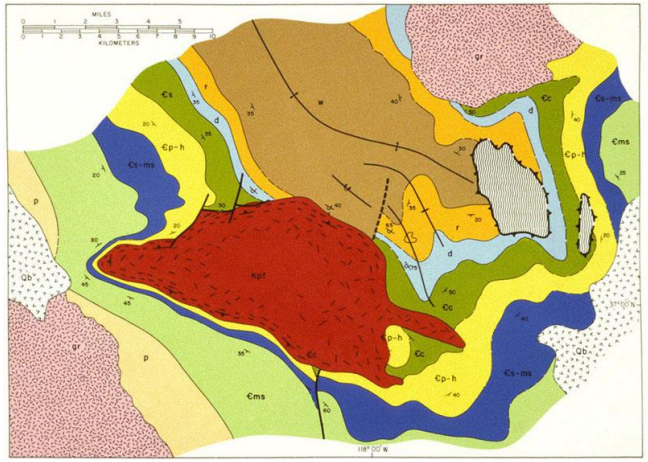
STEM Careers

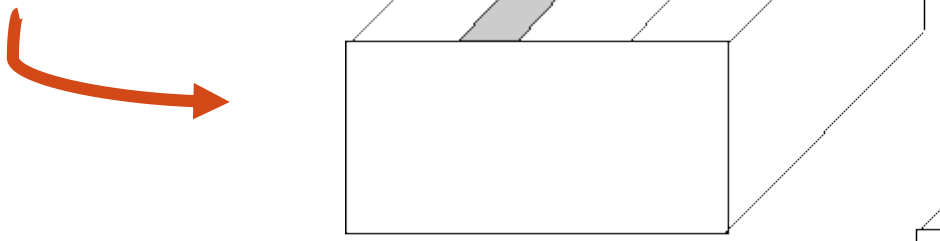


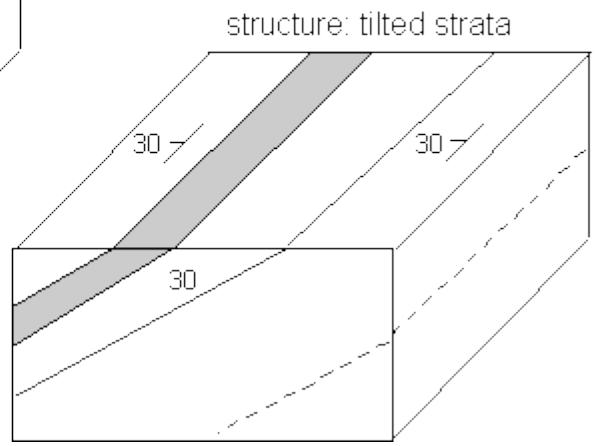
HOW?

Shea et al., 2001; Wai et al., 2009

What are visuospatial skills?







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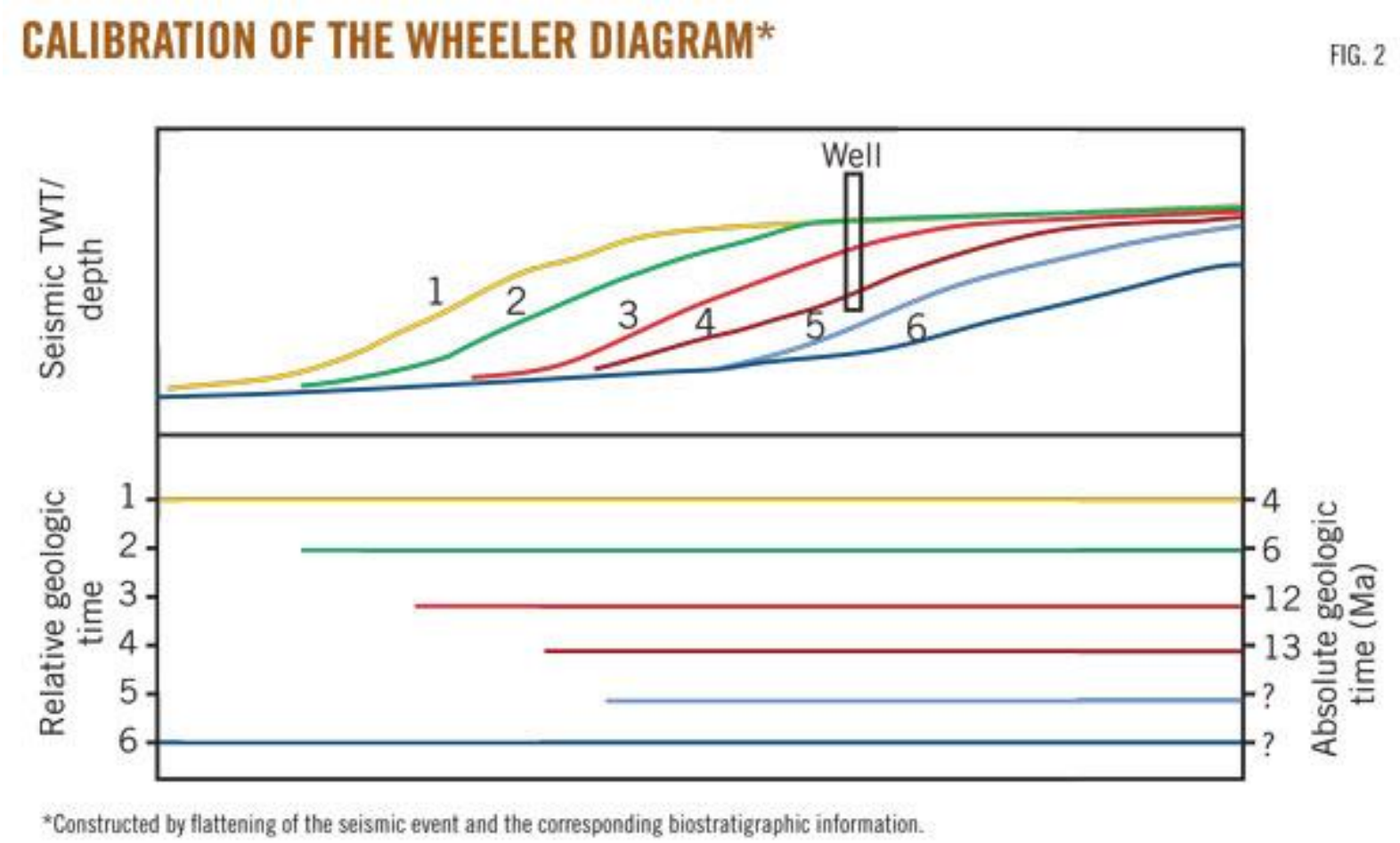
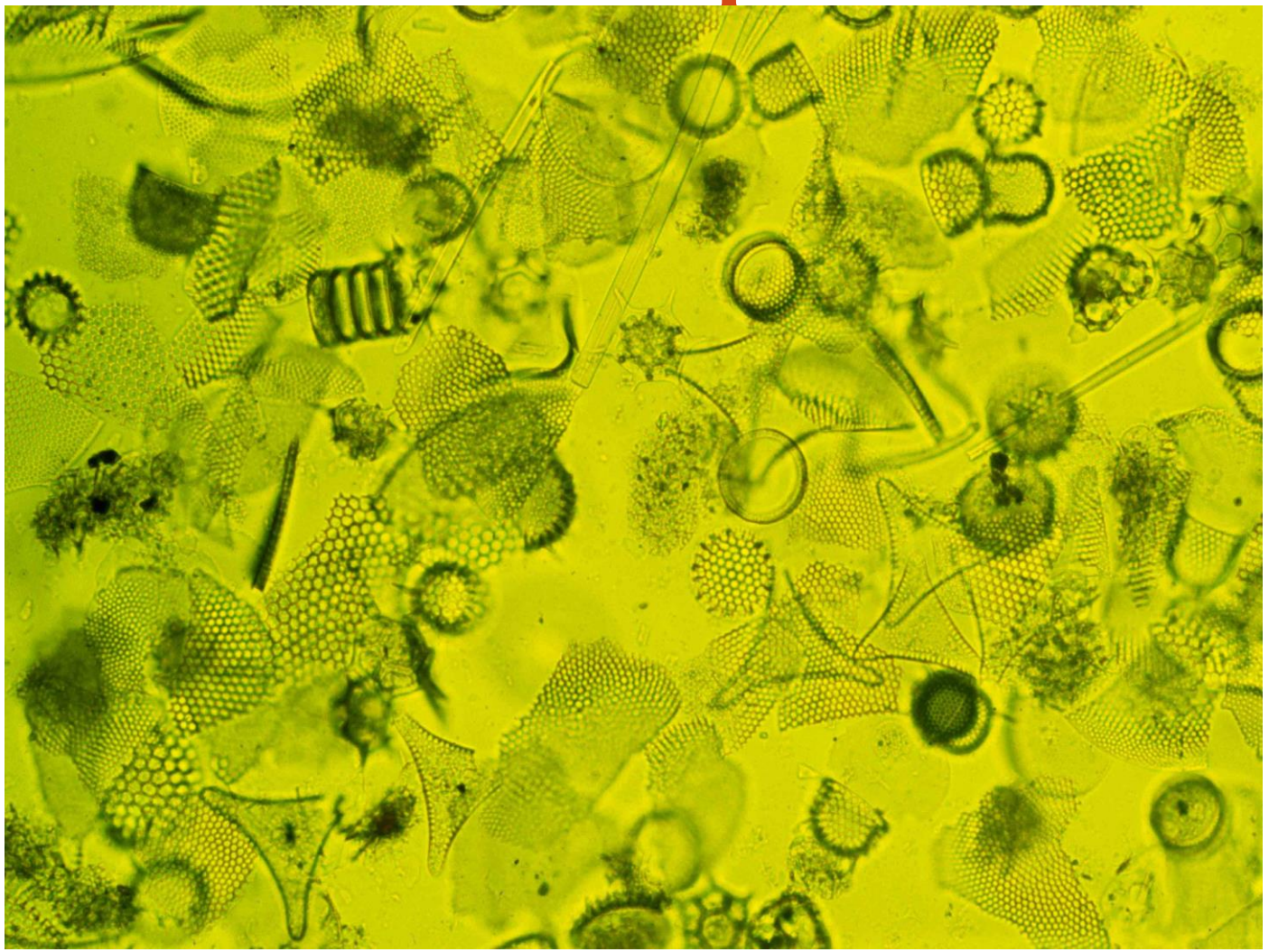


(Qayyum, F., Hemstra, N, Singh, R., 2013)

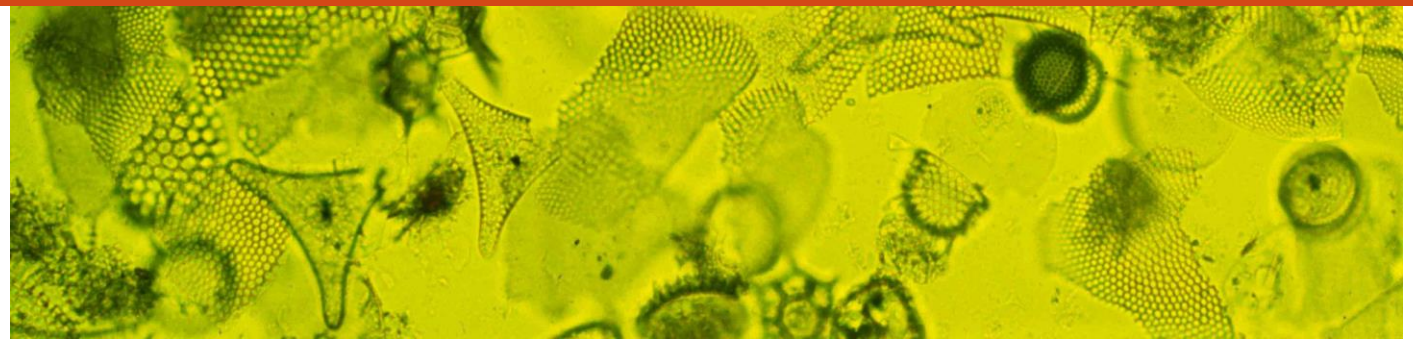
What are visuospatial skills?



Courtesy of R. Scherer, NIU)

What are visuospatial skills?

Domain Specific: Abilities and skills associated with particular setting



Courtesy of R. Scherer, NIU)

What are visuospatial skills?

Spatial Thinking Frameworks

- **Newcombe,** N. S., & Shipley, T. F. **(2012).** Thinking about spatial thinking: New typology, new assessments. *Studying visual and spatial reasoning for design creativity. New York, NY: Springer*.
- **Kastens**, K.A. and T. Ishikawa **(2006).** Spatial Thinking in Geosciences and Cognitive Sciences, in C. Manduca and D. Mogk (Eds.), *Earth & Mind: How Geoscientists Think and Learn about the Earth Earth*. Geological Society of America Special Publication 413
- **National Research Council. (2006).** *Learning to Think Spatially Spatially*. Washington, D.C.: National Academies Press.

Visuospatial Skills and K-12

1. Geoscience Assessments

2. Next Generation Science Standards (NGSS)

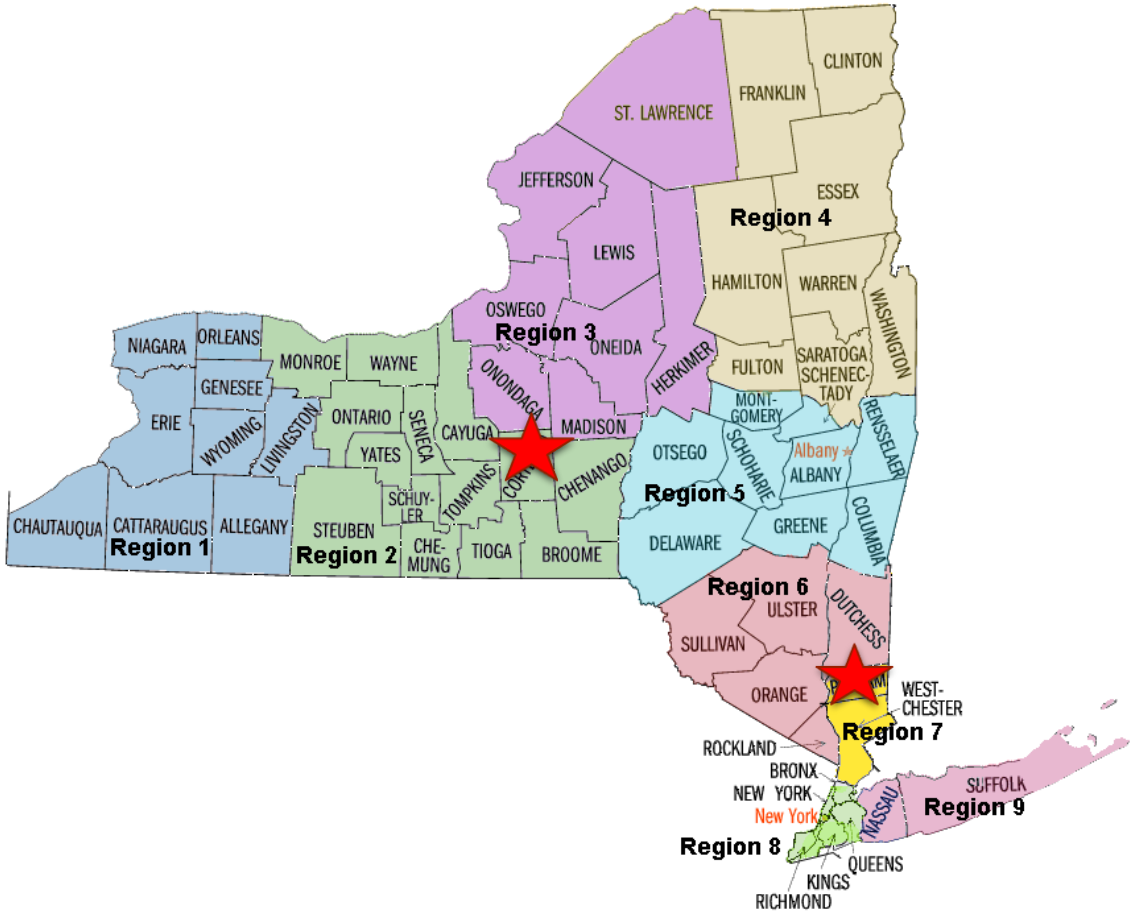
1. Visuospatial Skills and Geoscience Assessments

New York State Regents Exam

- Given in January, June, August
- Available online
- Focus on visual representations

Sample Population

- 144 Students (75 male)
- 9th Grade (m=14.6 years)
- 1 rural / 1 suburban
- 74% white



1. Visuospatial Skills and Geoscience Assessments

Text questions without ESRT (T)

2 The modern heliocentric model of planetary motion states that the planets travel around

(1) the Sun in slightly elliptical orbits
(2) the Sun in circular orbits
(3) Earth in slightly elliptical orbits
(4) Earth in circular orbits

All ESRT Questions (RT)

3 To an observer on Earth, the Sun appears brighter than the star *Rigel* because the Sun is

(1) hotter than *Rigel*
(2) more luminous than *Rigel*
(3) closer than *Rigel*
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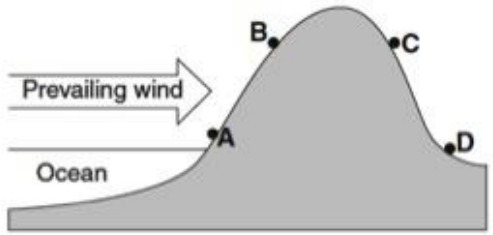
Visual Representation questions without the ESRT (V)

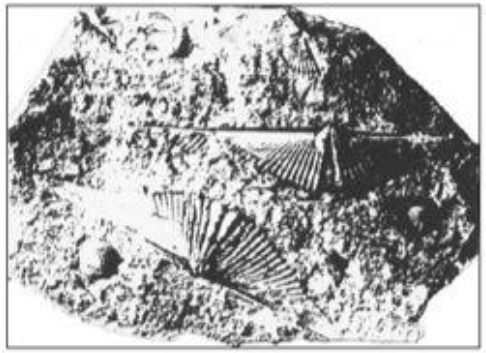
4 The cross section below represents four locations on a mountain. The arrow indicates the prevailing wind direction.



Which location has the warmest and most arid climate?

(1) *A*
(2) *B*
(3) *C*
(4) *D*

22 The photograph below shows index fossil shells found in bedrock in New York State.



These index fossil shells were most likely found in the surface bedrock of which landscape region?

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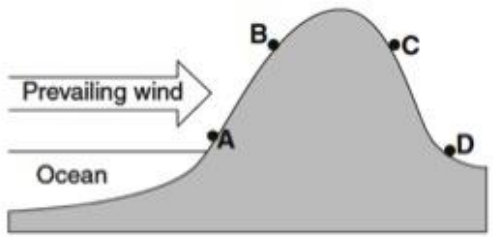

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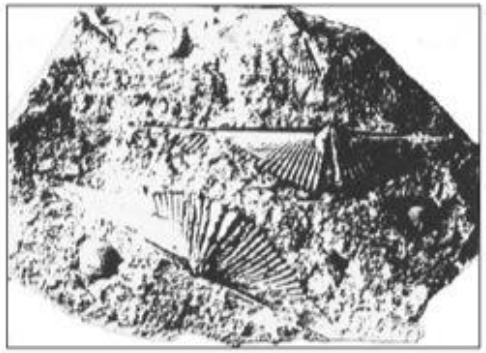

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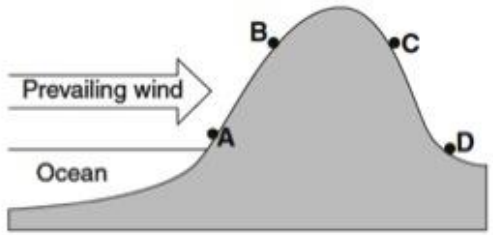

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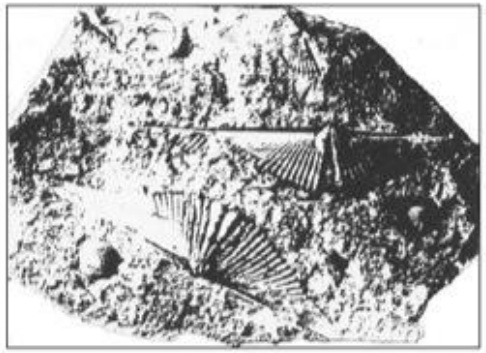

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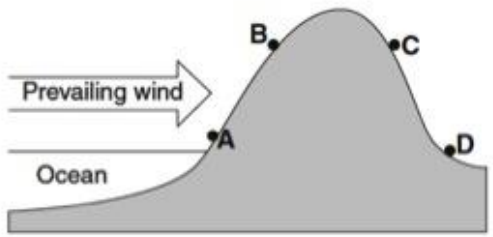

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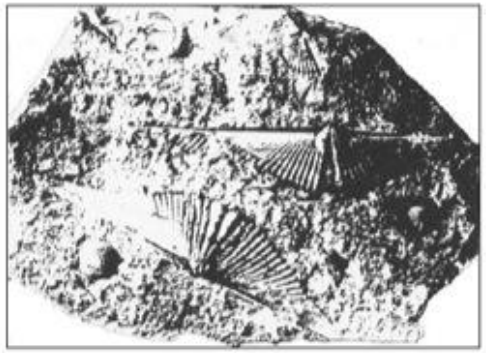

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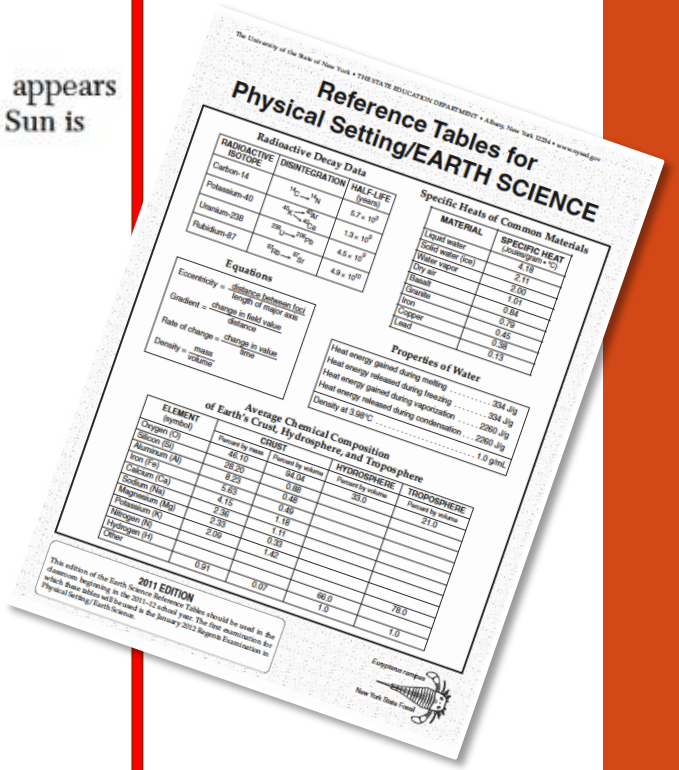
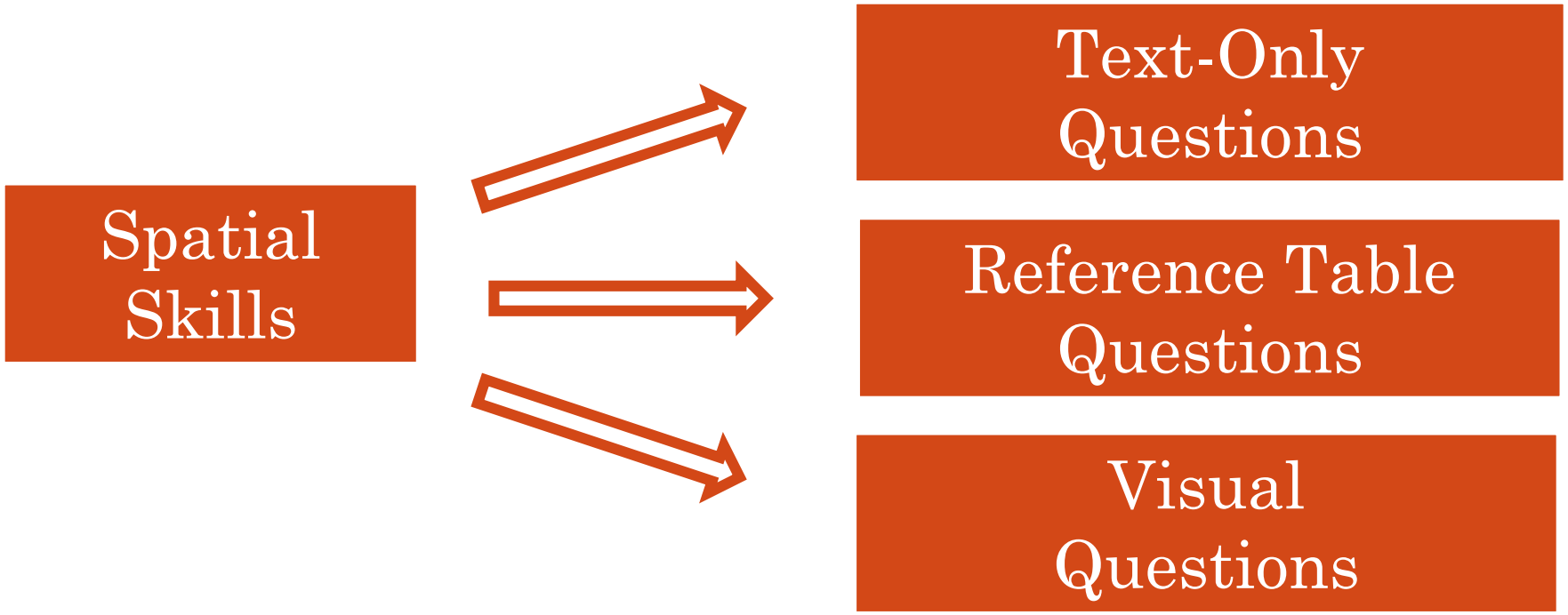


1. Visuospatial Skills and Geoscience Assessments

NYS Earth Science Regents Exam



LaDue & Hambrick, unpublished ms

1. Visuospatial Skills and Geoscience Assessments

	Text	Reference Table	Visual	Overall Regents
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* $p < .05$, all others $p < .01$

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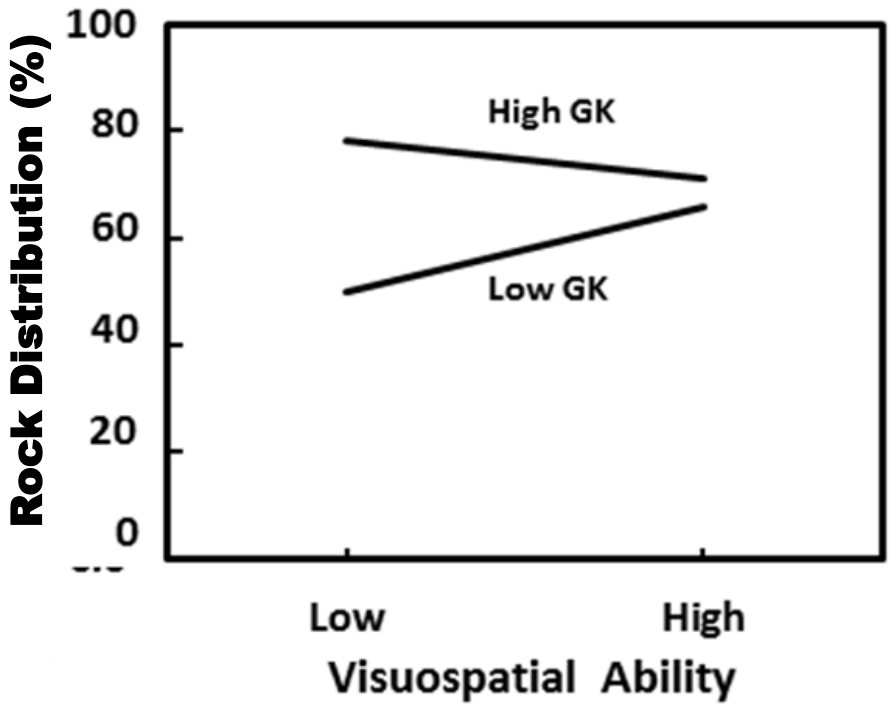


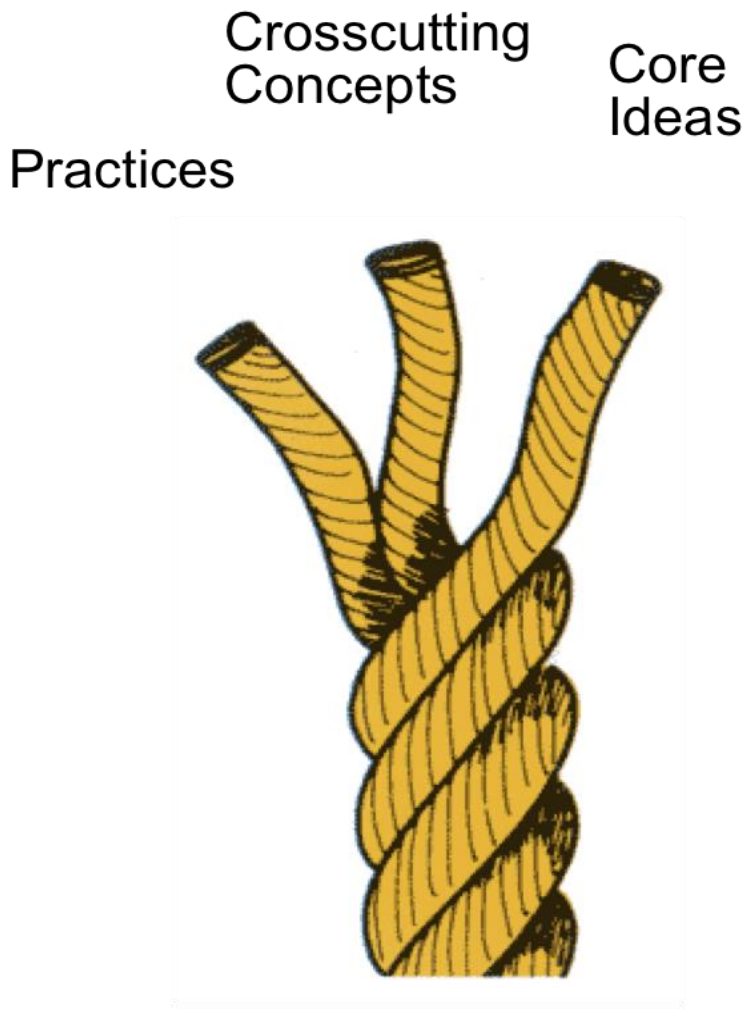
With the appropriate domain specific training,
domain general spatial skills may not influence performance

Hambrick et al., 2012

2. Visuospatial Skills and NGSS

Integration of 3 Dimensions:

1. Science & Engineering Practices
2. Crosscutting Concepts
3. Disciplinary Core Ideas



http://www.nextgenscience.org/

2. Visuospatial Skills and NGSS

Science and Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Developing explanations and designing solutions
7. Engaging in argument
8. Obtaining, evaluating, and communicating information

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2. Visuospatial Skills and NGSS

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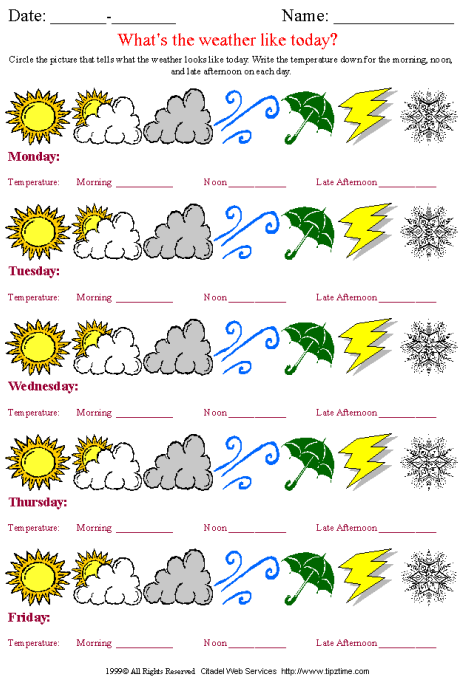
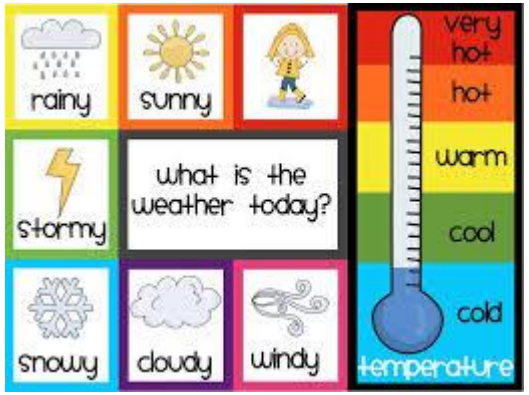
http://www.nextgenscience.org/

2. Visuospatial Skills and NGSS

- K-ESS2-1: Use and share observations of local weather conditions to describe patterns over time.
- 1-ESS1-1. Use observations of the sun, moon, and stars to describe patterns that can be predicted.

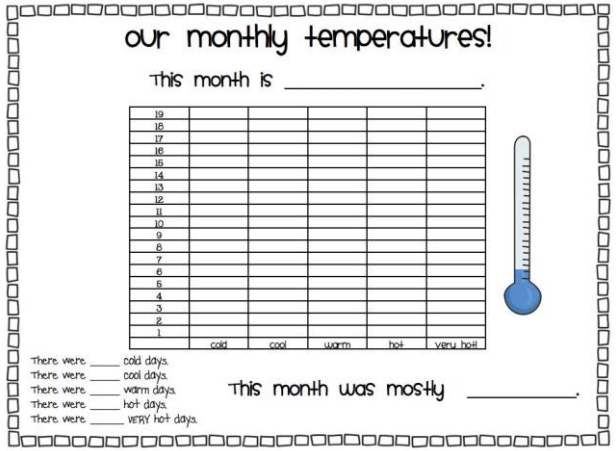




http://www.nextgenscience.org/

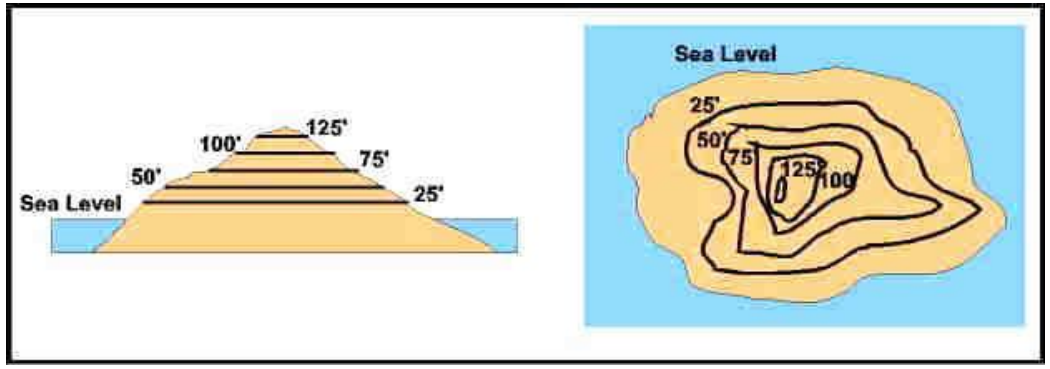
2. Visuospatial Skills and NGSS

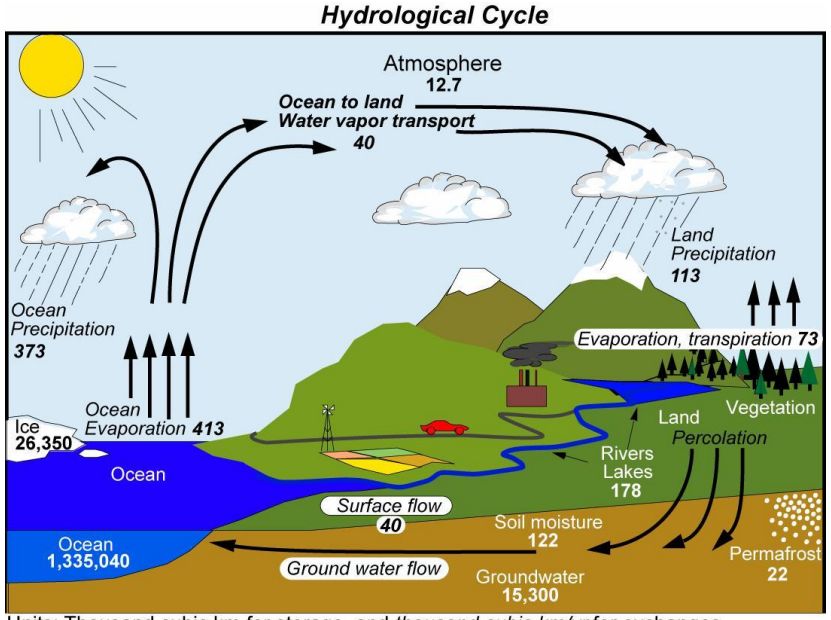
- 2-ESS2-2. Develop a model to represent the shapes and kinds of land and bodies of water in an area.
- 3-ESS2-1. Represent data in tables and graphical displays to describe typical weather conditions expected in a particular season. (Assessment of graphical displays is limited to pictographs and bar graphs)



2. Visuospatial Skills and NGSS

- 4-ESS2-2. Analyze and interpret data from maps to describe patterns of Earth's features (ex. can include topomaps)
- 5-ESS2-1 Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.

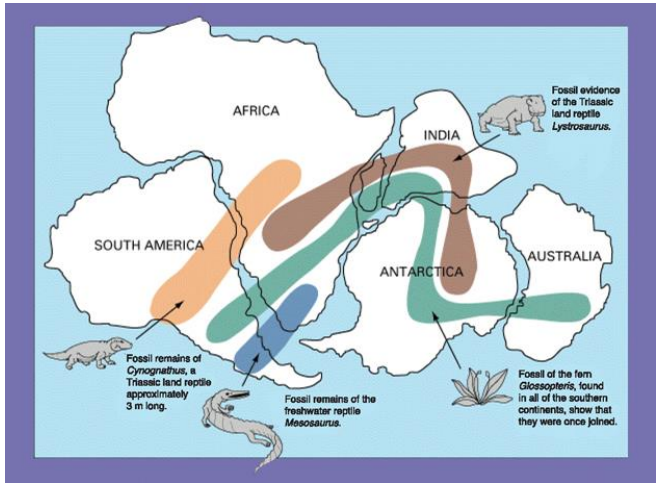




http://www.nextgenscience.org/

2. Visuospatial Skills and NGSS

- MS-ESS1-1. Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.
- MS-ESS2-3. Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.



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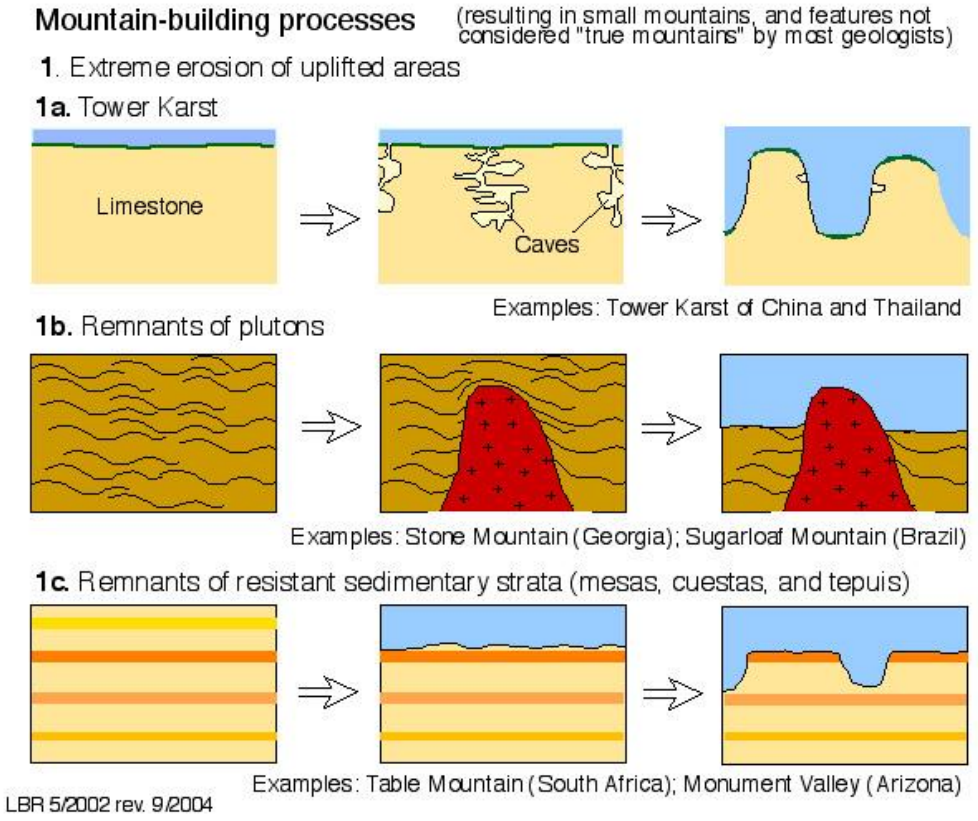
2. Visuospatial Skills and NGSS

- HS-ESS2-1. Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.



http://www.nextgenscience.org/

www.gly.uga.edu

2. Visuospatial Skills and NGSS

- **Early Development of Spatial Thinking** (Newcombe & Frick, 2010)
  - Elementary school
  - Object vesus Embodied Perspective

2. Visuospatial Skills and NGSS

- Early Development of Spatial Thinking (Newcombe & Frick, 2010)
- **Models** (Rivet, A. E., & Kastens, K. A., 2012).
  - High School, table-top models
  - Analogical Reasoning: compare and contrast model attributes

2. Visuospatial Skills and NGSS

- Early Development of Spatial Thinking (Newcombe & Frick, 2010)
- Models (Rivet, A. E., & Kastens, K. A., 2012).
- **Analogical Reasoning** (Jee, B.D., Uttal, D.H., Gentner, D., Manduca, C., Shipley, T.F., Tikoff, B., Ormand,C.J., and Sageman, B., 2010)
  - Move from surface similarity to abstract concepts
  - Identify incorrect inferences

2. Visuospatial Skills and NGSS

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- Analogical Reasoning (Jee, B.D. et al., 2010)
- **Sketching** (Jee, B. D., Gentner, D., Uttal, D. H., Sageman, B., Forbus, K., Manduca, C. A., ... & Tikoff, B. (2014).
  - More Knowledge = More structures and causal relations in sketches

Next Steps

- **Connecting Spatial Framework with Assessment Data** (Kastens, K. A., Pistolesi, L., & Passow, M. J., 2014)
- Review Article aligning existing literature with K-12 activities
- Evaluating existing college-level spatial activities with K-12 students

Next Steps

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- **Review article aligning existing literature with K-12 activities**
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What do your students see?

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