Strengthening Students' Spatial Thinking Skills

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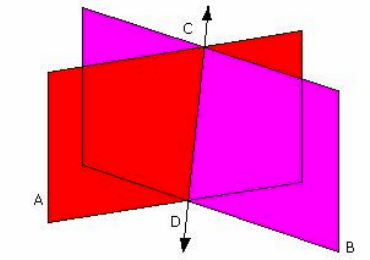
Overview

- How can errors be useful?
- Spatial Feedback & Accommodation
- Classroom Examples
  - Small Classes
  - Large Classes

Errors in 3D Reasoning in Geology



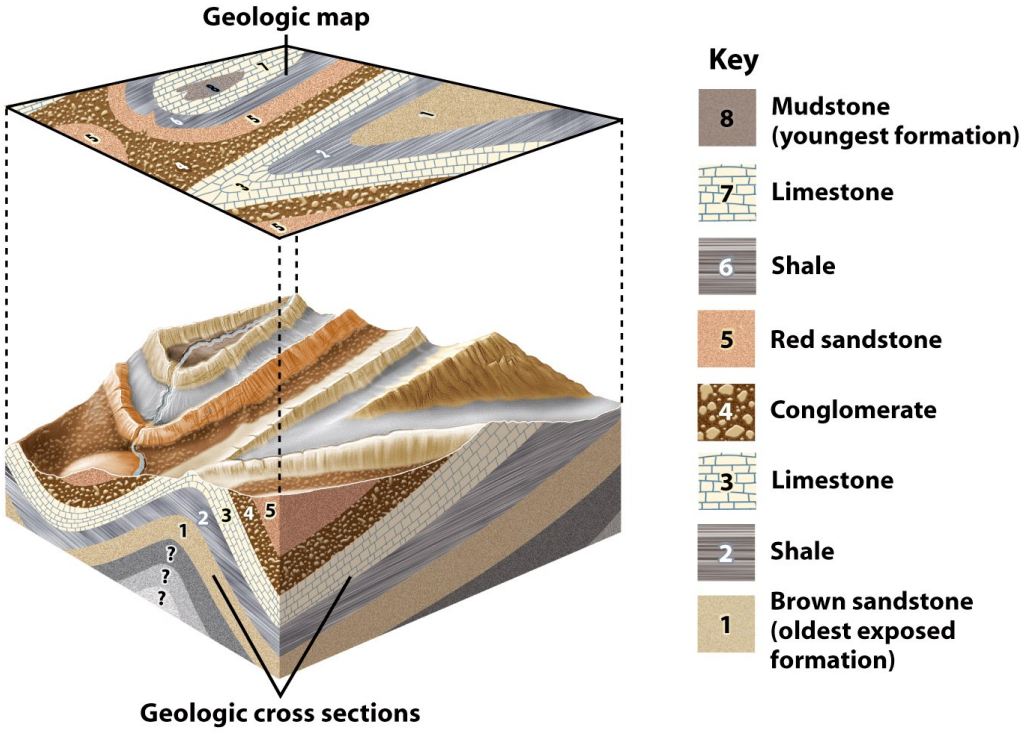
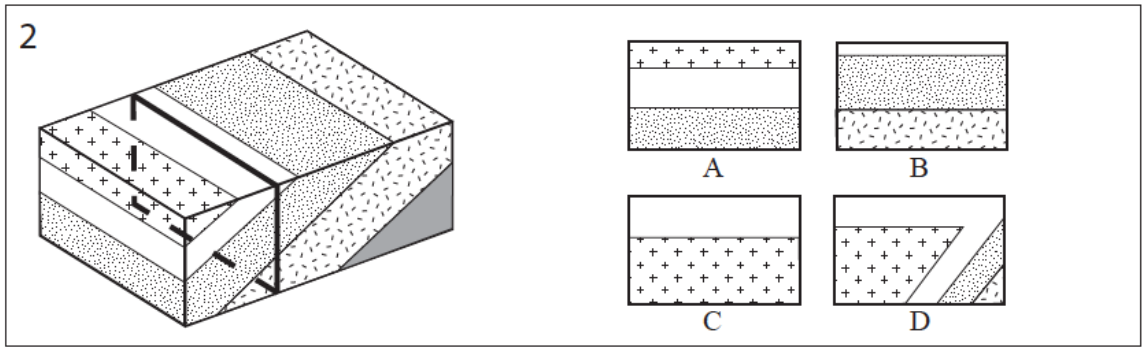
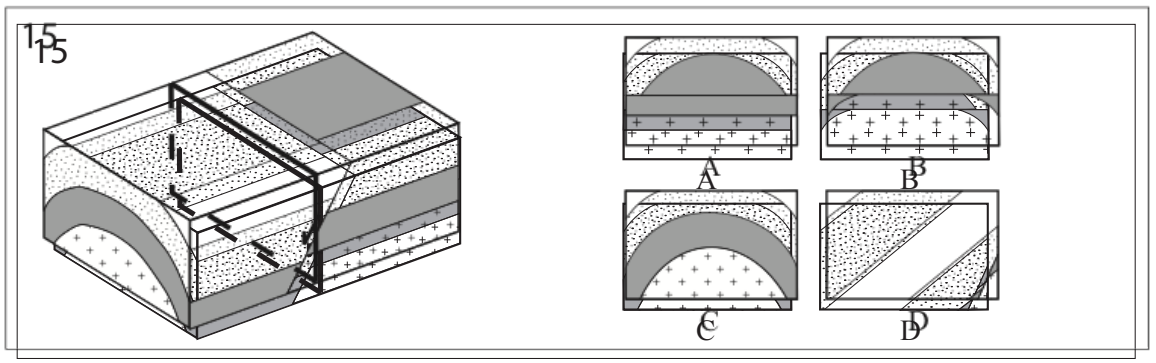


Figure 7-4
Understanding Earth, Fifth Edition

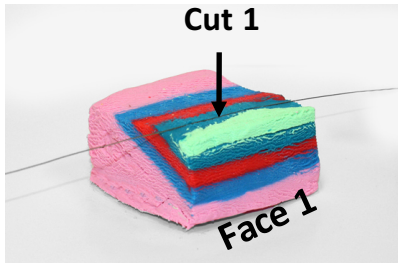
Measuring 3D Slicing Skill

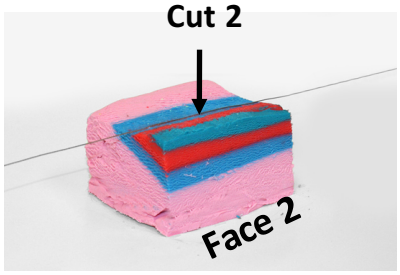
Developmental progression:
No idea->use one side-> interpolate using multiple sides

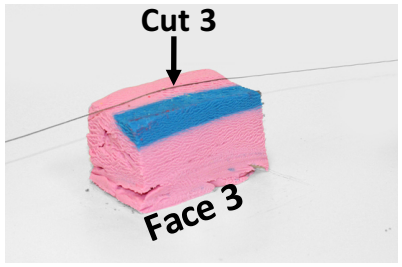




Sketching to Improve the Internal Model



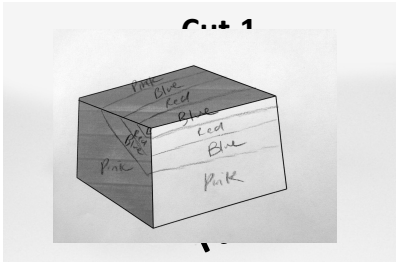


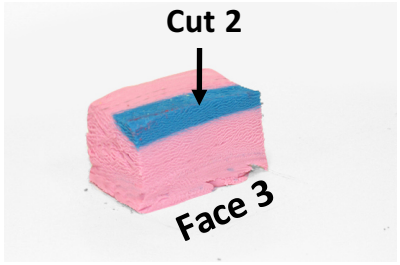


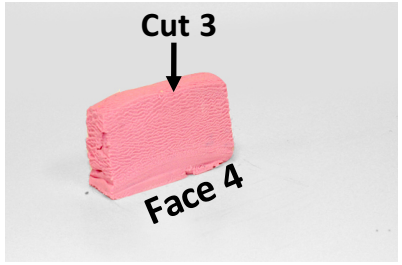
CROSS-SECTION

CROSS-SECTION

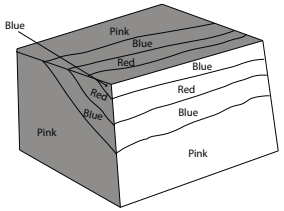
CROSS-SECTION







SKETCH



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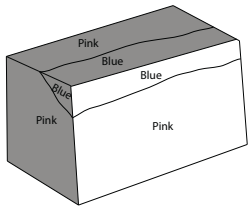

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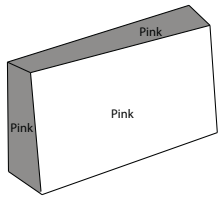
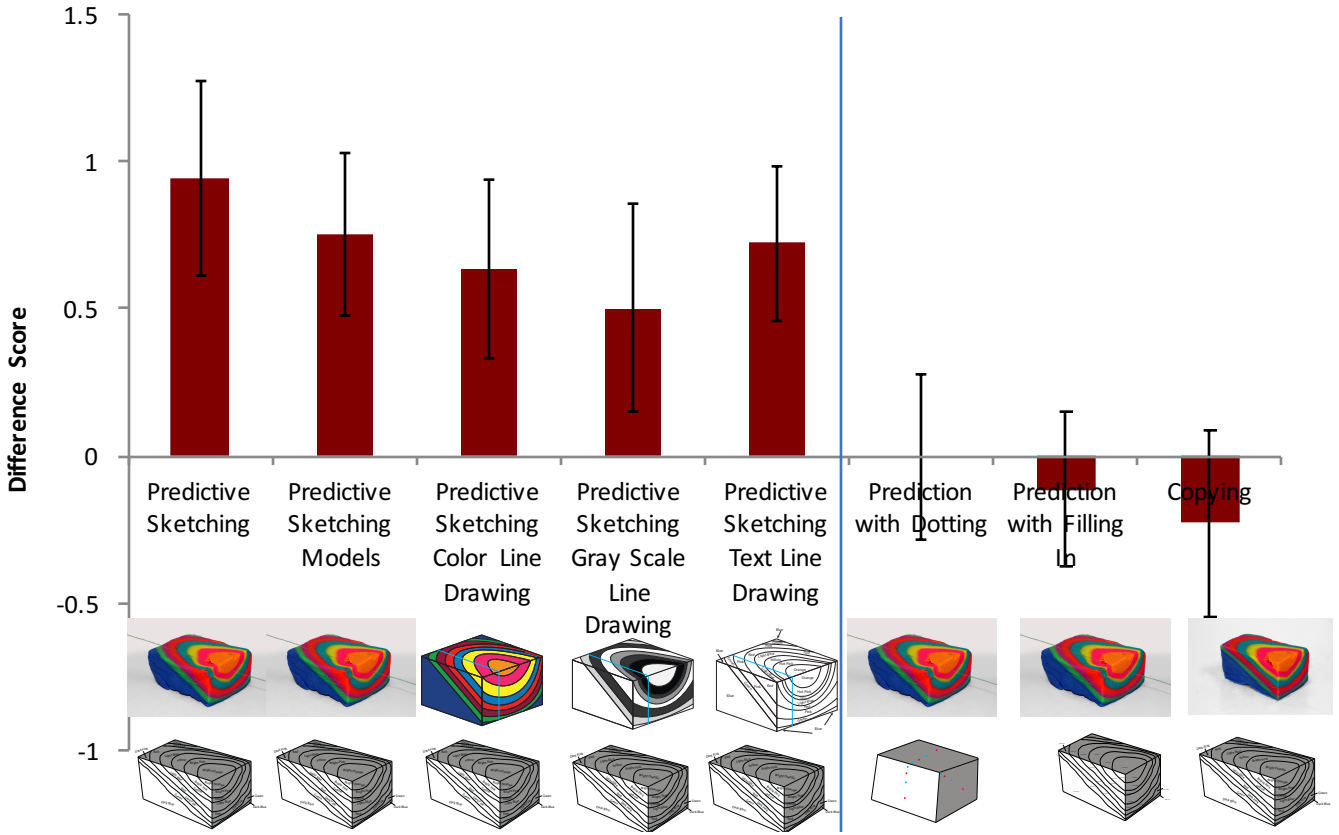
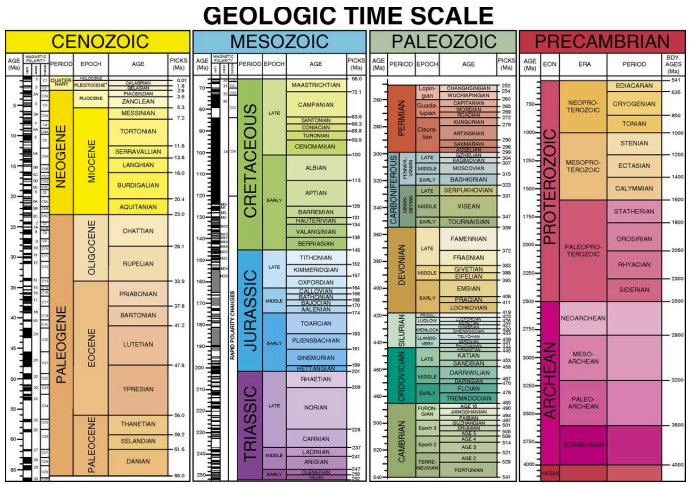


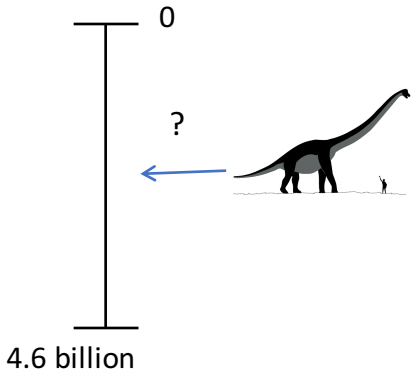
Max # Sketches 12

Predictive Sketching Improves 3D Reasoning

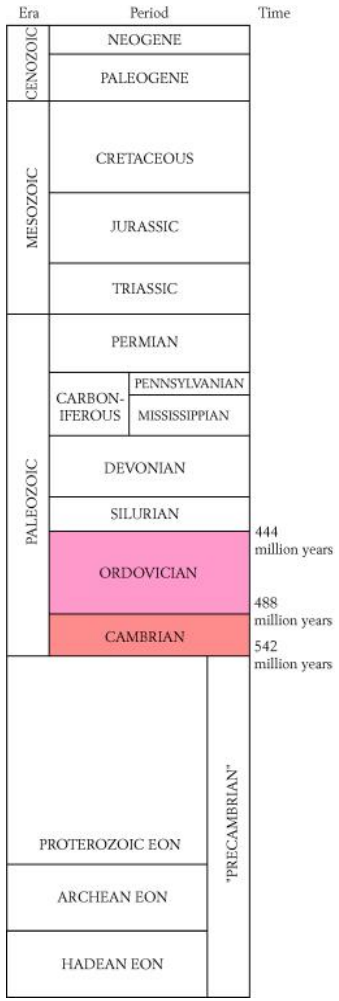


Scale-Time


GEOLOGIC TIME SCALE
CENOZOIC
MESOZOIC
PALEOZOIC
PRECAMBRIAN
NEOGENE
PALEOGENE
MIOCENE
OLIGOCENE
EOCENE
PALEOCENE
CRETACEOUS
JURASSIC
TRIASSIC
PERMIAN
CARBONIFEROUS
DEVONIAN
SILURIAN
ORDOVICIAN
CAMBRIAN
PROTEROZOIC
ARCHEAN
MAASTRICHTIAN
CAMPANIAN
SANTONIAN
CONIACIAN
TURONIAN
CENOMANIAN
ALBIAN
APTIAN
BARREMIAN
HAUTERIVIAN
VALANGINIAN
BERRIASIAN
TITHONIAN
KIMMERIDGIAN
OXFORDIAN
CALLOVIAN
BATHONIAN
BAJOCIAN
AALENIAN
TOARCIAN
PLIENSBACHIAN
SINEMURIAN
HETTANGIAN
RHAETIAN
NORIAN
CARNIAN
LADINIAN
ANISIAN
MESSINIAN
TORTONIAN
SERRAVALLIAN
LANGHIAN
BURDIGALIAN
AQUITANIAN
CHATTIAN
RUPELIAN
PRIABONIAN
BARTONIAN
LUTETIAN
YPRESIAN
THANETIAN
SELANDIAN
DANIAN
CHANGHSINGIAN
WUCHIAPINGIAN
CAPITANIAN
WORDIAN
ROADIAN
KUNGURIAN
ARTINSKIAN
SAKMARIAN
ASSELIAN
KASIMOVIAN
MOSCOVIAN
BASHKIRIAN
SERPUKHOVIAN
VISEAN
TOURNAISIAN
FAMENNIAN
FRASNIAN
GIVETIAN
EIFELIAN
EMSIAN
PRAGUIAN
LOCHKOVIAN
PRIDOLI
LUDLOW
WENLOCK
LLANDOVERY
KATIAN
SANDBIAN
DARRIWILIAN
DAPINGIAN
FLOIAN
TREMADOCIAN
FURONGIAN
STAGE 10
JIANGSHANIAN
PAIBIAN
GUZHANGIAN
DRUMIAN
STAGE 5
Epoch 3
STAGE 4
Epoch 2
STAGE 3
STAGE 2
TERRENEUVIAN
FORTUNIAN
NEOPROTEROZOIC
MESOPROTEROZOIC
PALEOPROTEROZOIC
NEOARCHEAN
MESOARCHEAN
PALEOARCHEAN
EOARCHEAN
EDIACARAN
CRYOGENIAN
TONIAN
STENIAN
ECTASIAN
CALYMMIAN
STATHERIAN
OROSIRIAN
RHYACIAN
SIDERIAN


0
?
4.6 billion

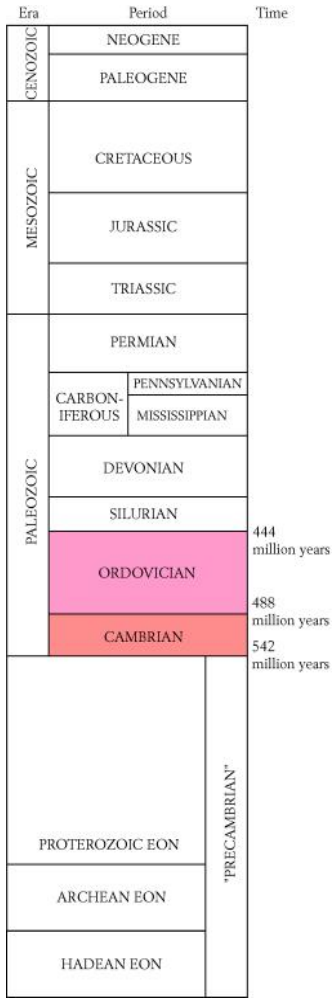
Phanerozoic Eon
Paleozoic Era
Cambrian & Ordovician Periods
(Early Paleozoic)

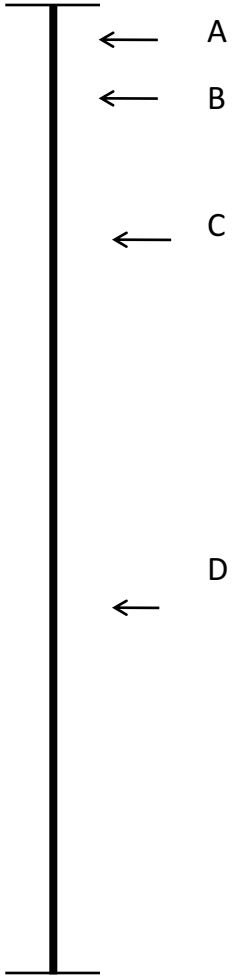


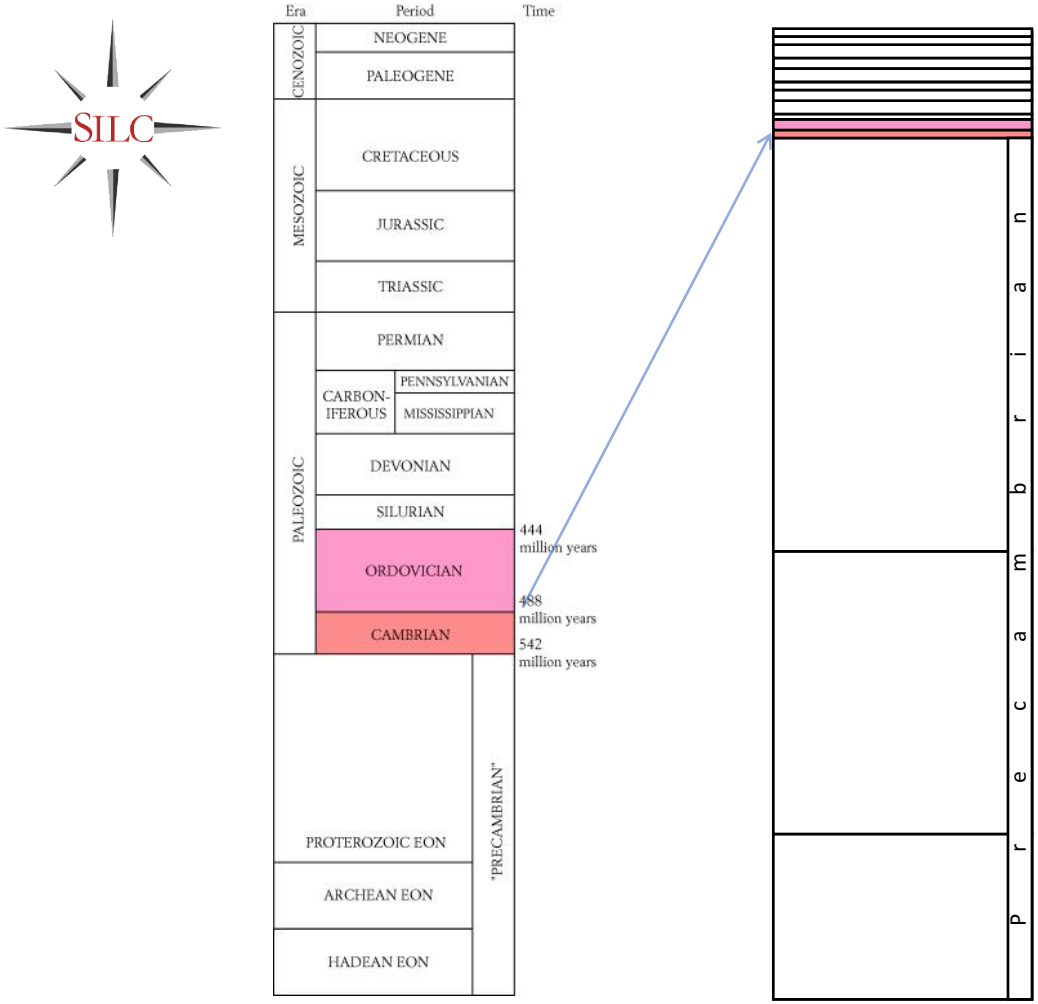
Today we are going to talk about the Cambrian & Ordovician Periods.

You can see them highlighted on the Geologic Time Scale.

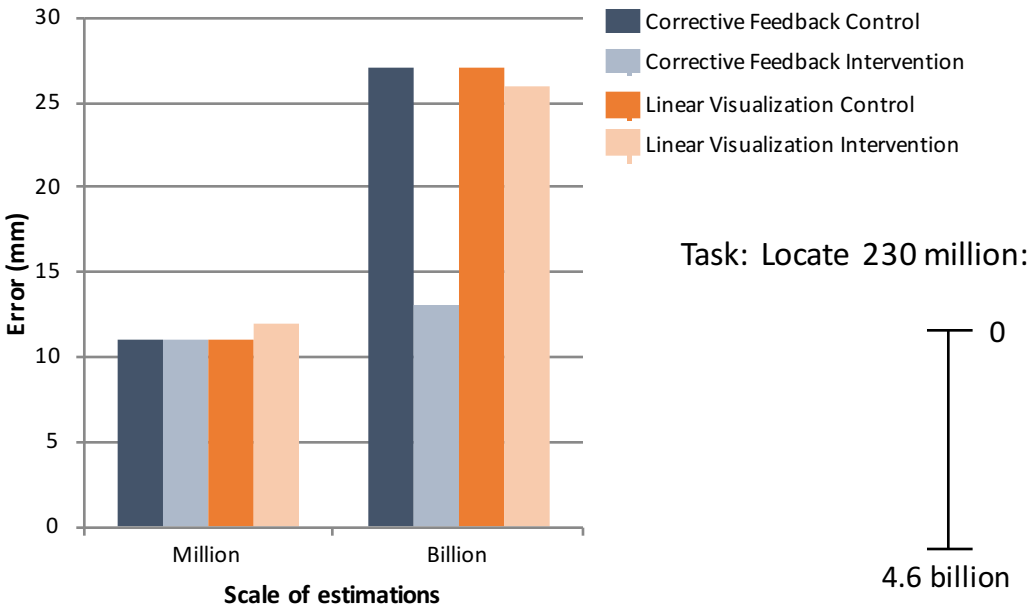
Where would these periods be located on the linear time scale on the right?



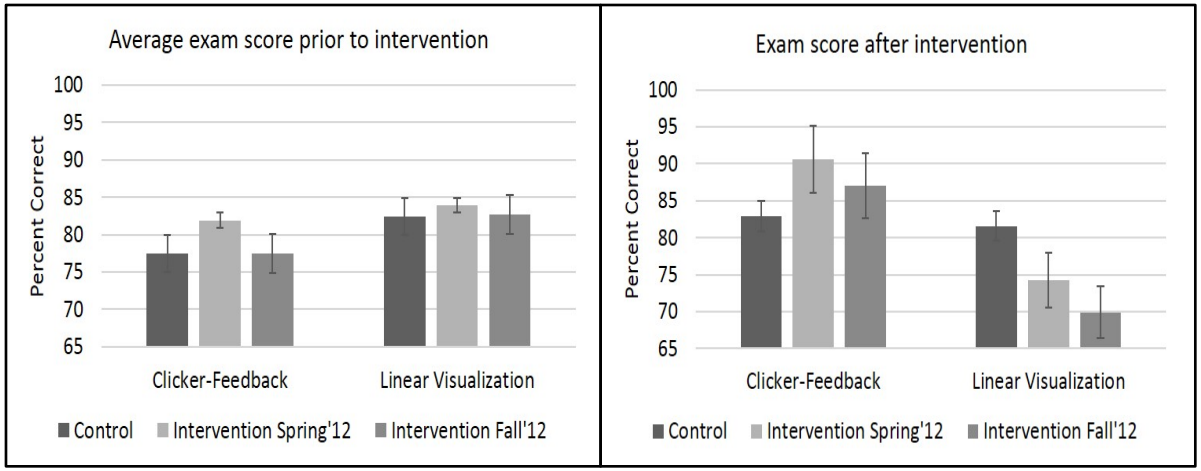



SILC
Era
Period
Time
CENOZOIC
NEOGENE
PALEOGENE
MESOZOIC
CRETACEOUS
JURASSIC
TRIASSIC
PALEOZOIC
PERMIAN
CARBON-IFEROUS
PENNSYLVANIAN
MISSISSIPPIAN
DEVONIAN
SILURIAN
ORDOVICIAN
CAMBRIAN
444 million years
488 million years
542 million years
"PRECAMBRIAN"
PROTEROZOIC EON
ARCHEAN EON
HADEAN EON
Precambrian

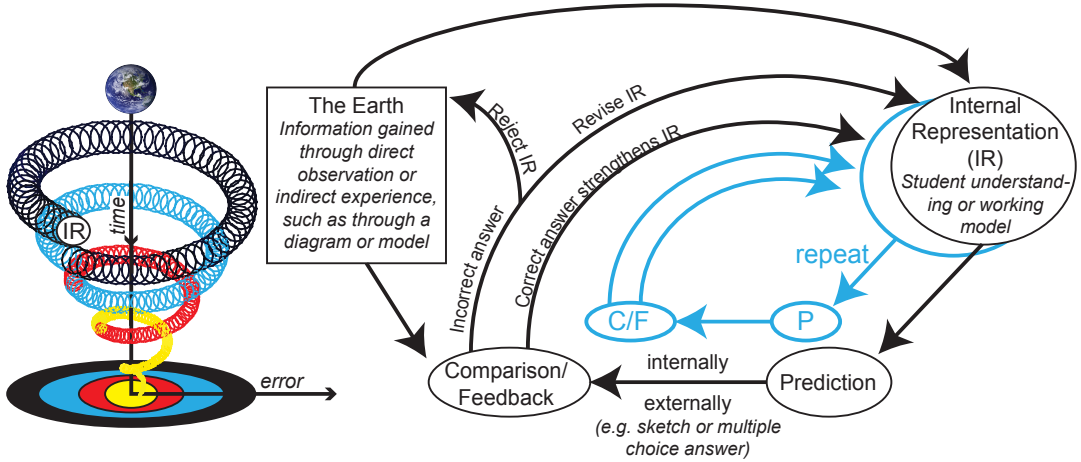
Linear use of billion scale



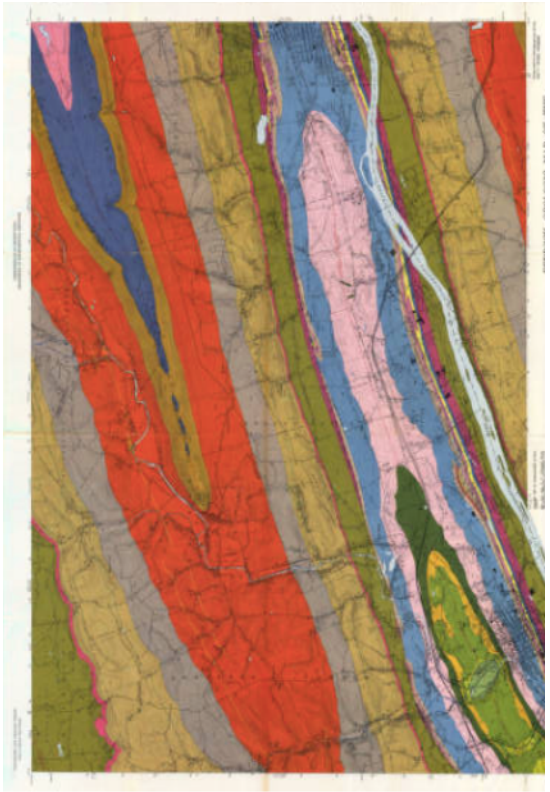
Grades


Average exam score prior to intervention
Percent Correct
100
95
90
85
80
75
70
65
Clicker-Feedback
Linear Visualization
Control
Intervention Spring'12
Intervention Fall'12
Exam score after intervention
Percent Correct
100
95
90
85
80
75
70
65
Clicker-Feedback
Linear Visualization
Control
Intervention Spring'12
Intervention Fall'12

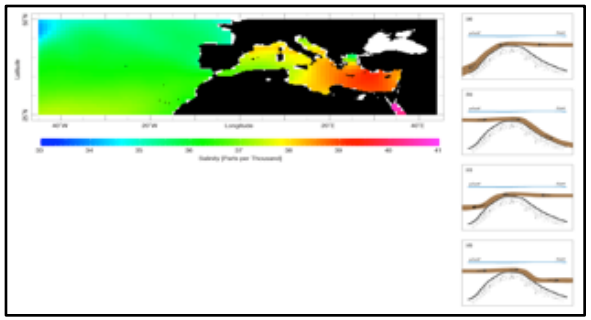
Correcting an Internal Model



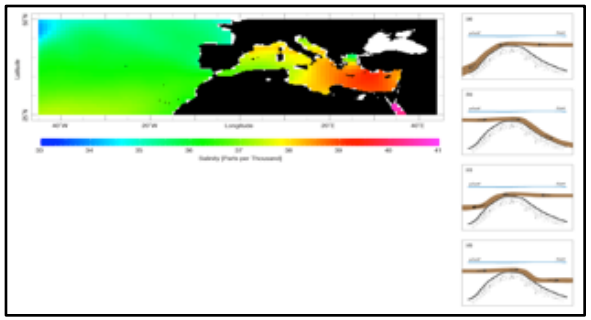
Spatial Accommodation
Providing a 3D structural model

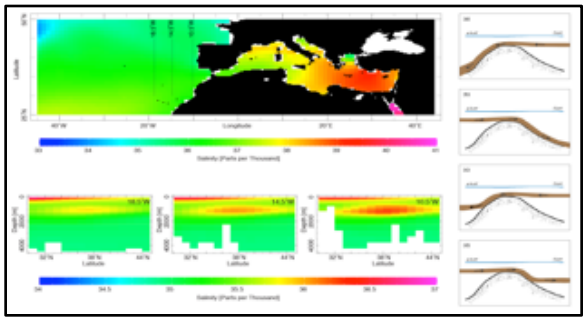


Spatial Accommodation
Providing a model as a hypothesis template

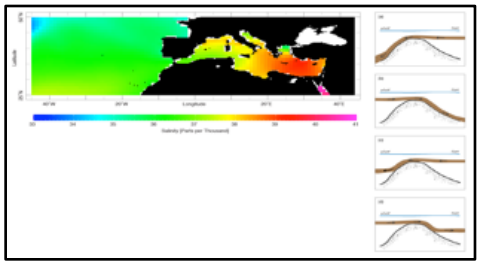


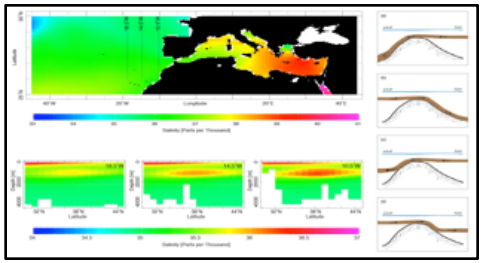
Spatial Accommodation
Providing a model as a hypothesis template

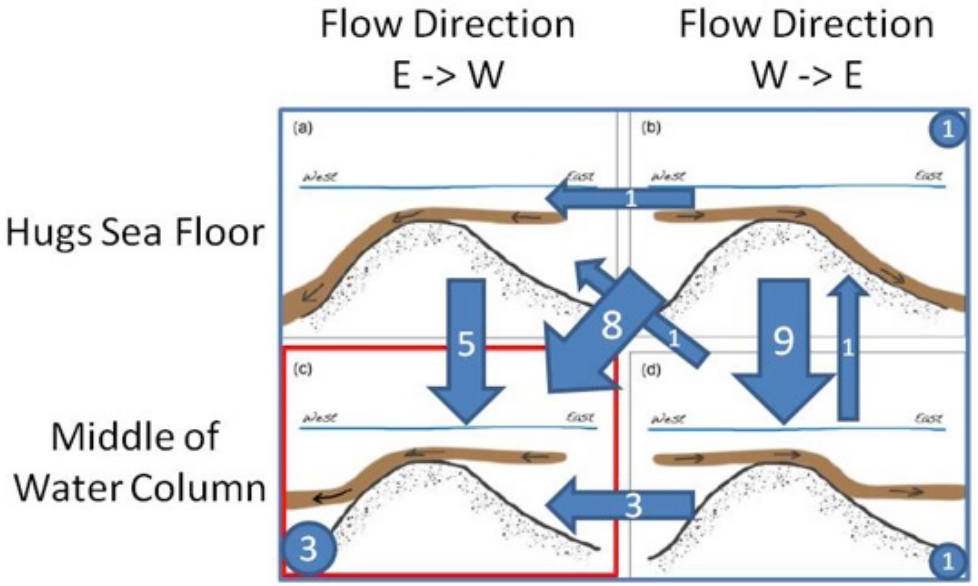




Spatial Accommodation
Providing a model as a hypothesis template

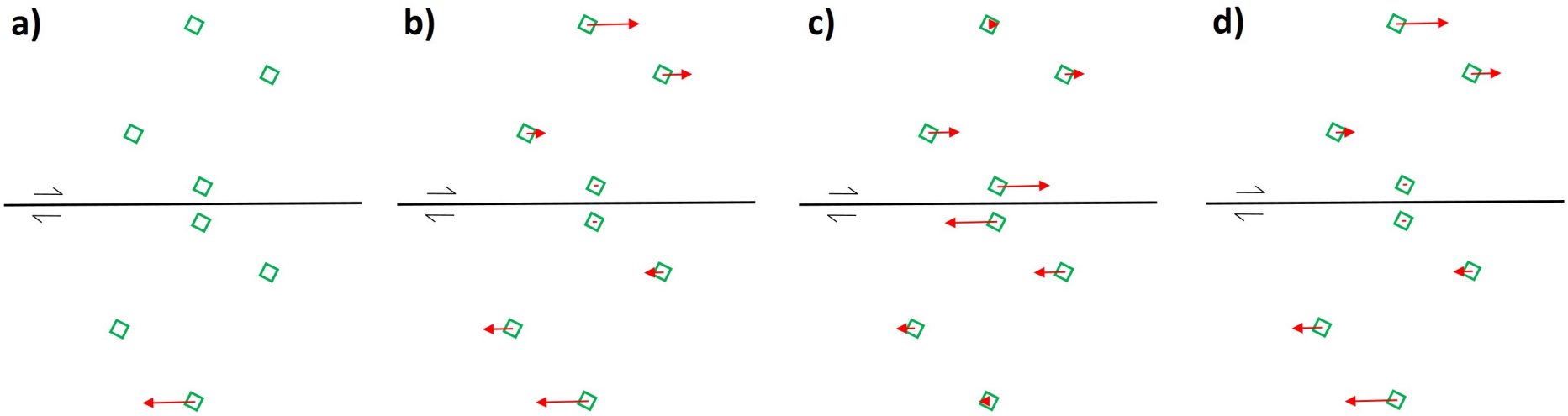






Spatial Accommodation & Feedback

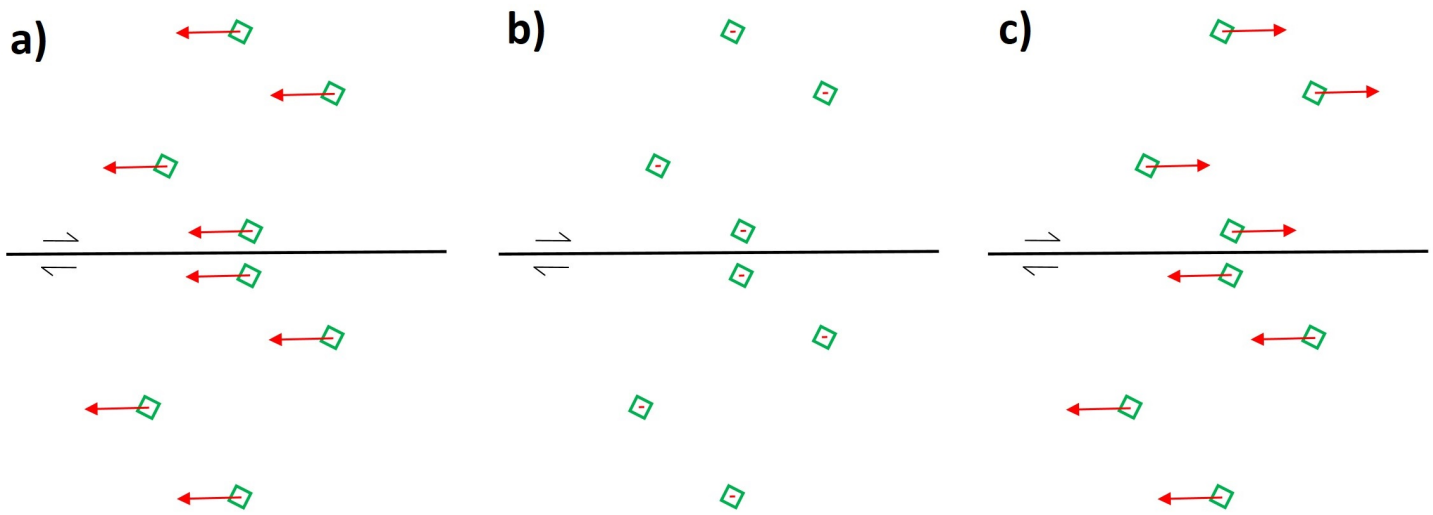
Observation: GPS Vectors of Strain near a Fault



Initial Condition Before During After

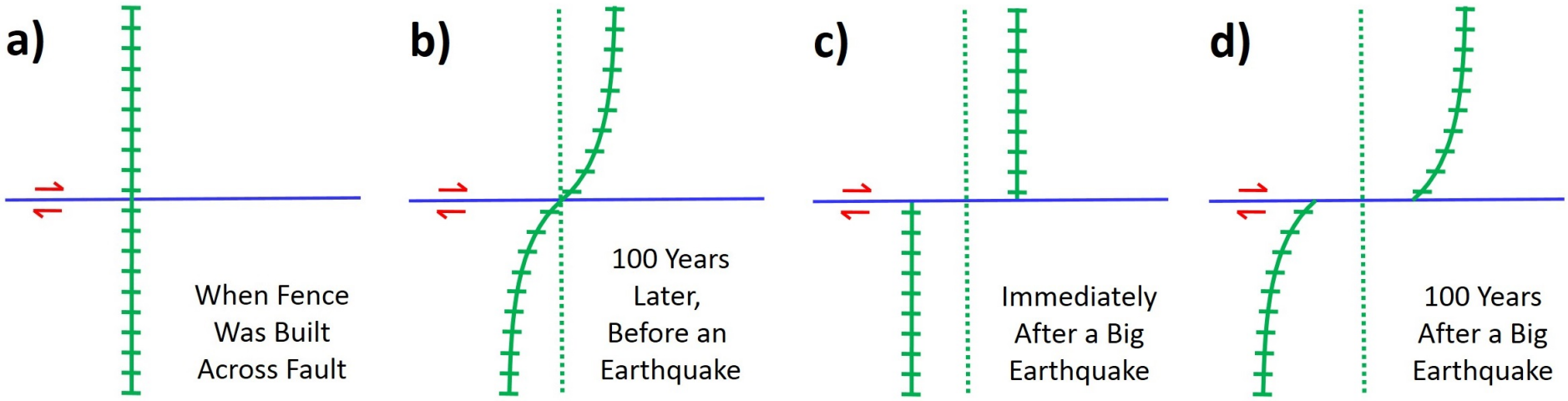
Spatial Accommodation & Feedback

Error: What students think it will look like before…

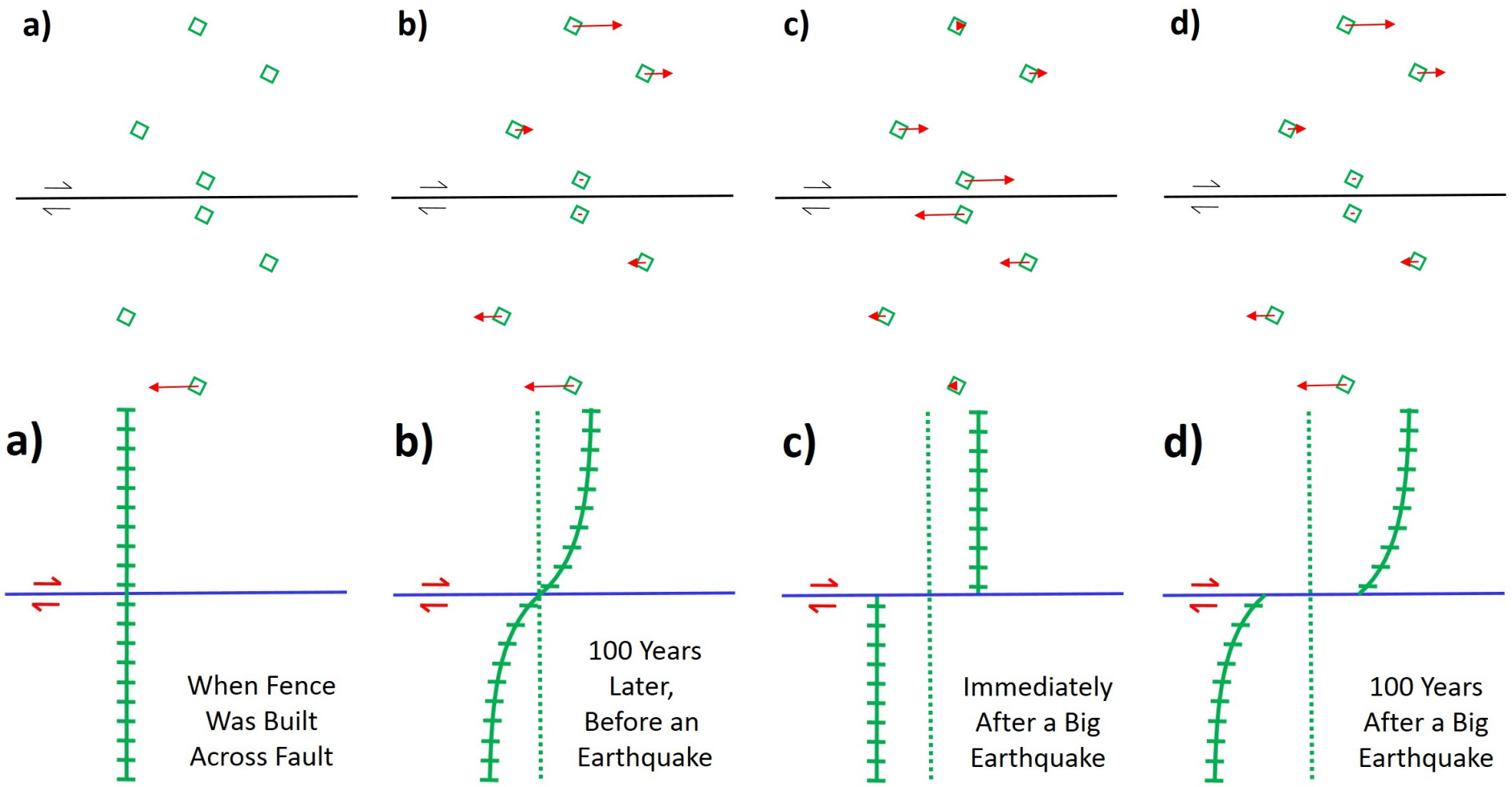


Spatial Accommodation & Feedback

Observation: Strain near a Fault - FENCE

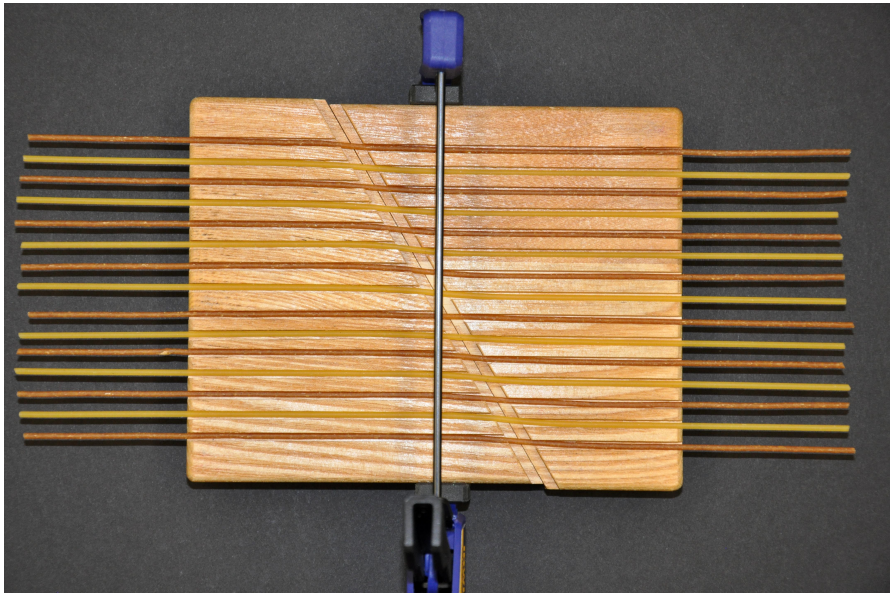


Initial Condition Before During After


a)
b)
c)
d)
a)
b)
c)
d)
When Fence Was Built Across Fault
100 Years Later, Before an Earthquake
Immediately After a Big Earthquake
100 Years After a Big Earthquake

Spatial Accommodation & Feedback

Modeling to Facilitate Accommodation



Engaging Large Classes in Spatial Feedback & Accommodation

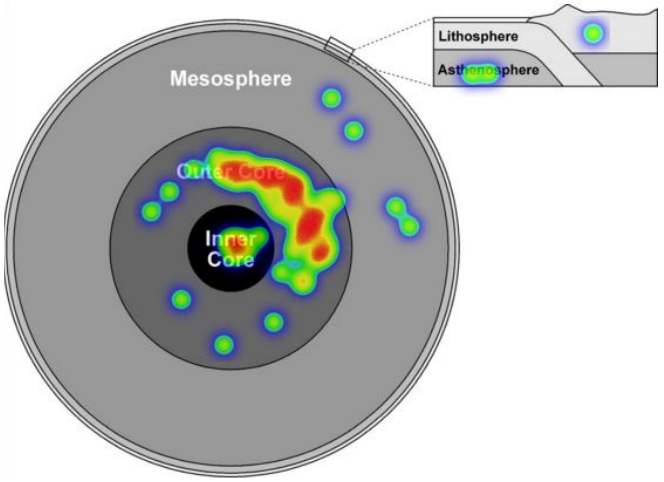
Multiple-Choice

Which layer of Earth's interior is entirely liquid?

A. Lithosphere
B. Mesosphere
C. Outer core
D. Inner core

Click-on-Diagram

Click on the layer of Earth's interior that is entirely liquid.



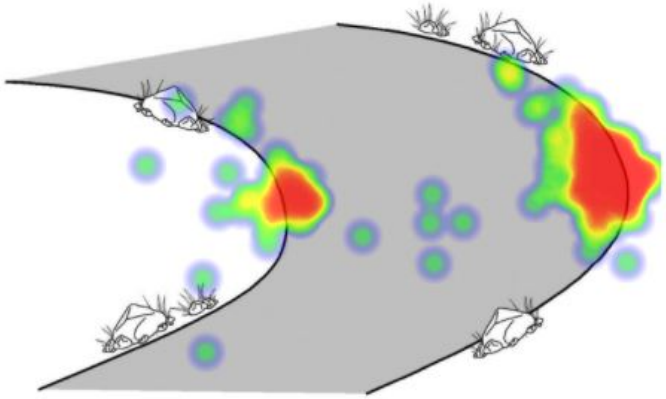
Spatial Categories

Spatial Category	Example	Spatial Cognitive Process
Spatial Integration	Combining field observations to construct a geologic explanation (Shipley et al. 2013)	Spatial Visualization (Newcombe and Shipley 2012)
Scaler Relationships	Spacing of geologic events in deep time (Libarkin et al. 2007)	Spatial Visualization (Newcombe and Shipley 2012)
Spatial Reference Frame	Mentally animating the geologic processes forming a static structure (Shipley et al. 2013)	Mental Animation (Newcombe and Shipley 2012) Perspective Taking (Hegarty and Waller 2004) Retrodiction (Ault 1998; Trend 2000)

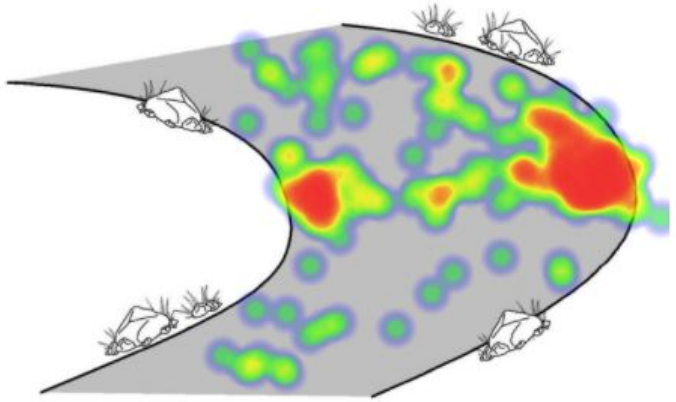
Spatial Integration

Combining field observations to construct a geologic explanation

Click where you expect to find the greatest erosion



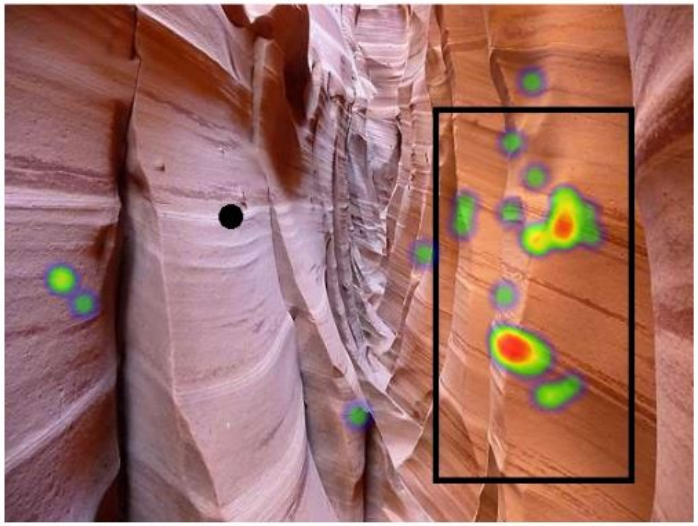
Click where you expect to find the fastest moving water



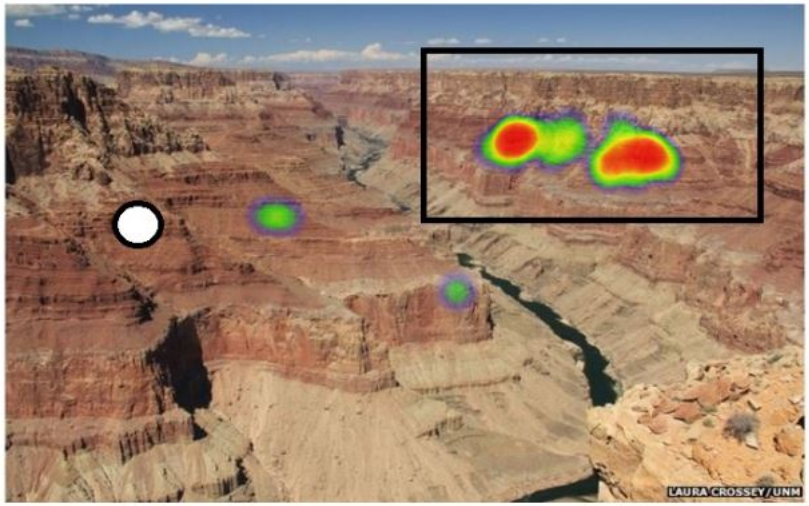
Spatial Integration

Combining field observations to construct a geologic explanation

Click in the box where you see the same later of rock as the one labeled with the dot



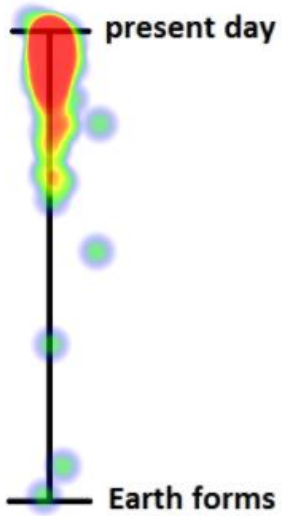
Click in the box where you see the same later of rock as the one labeled with the dot



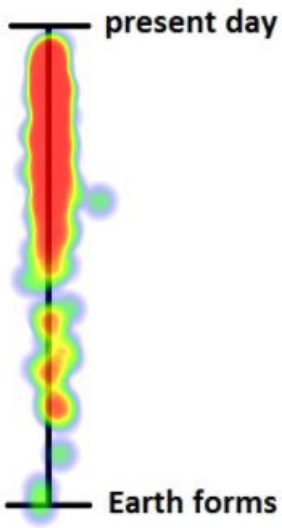
Scalar Relationship

Spacing of geologic events/objects in deep time/space

Click where you expect humans appeared



Click where you expect dinosaurs appeared



Scalar Relationship

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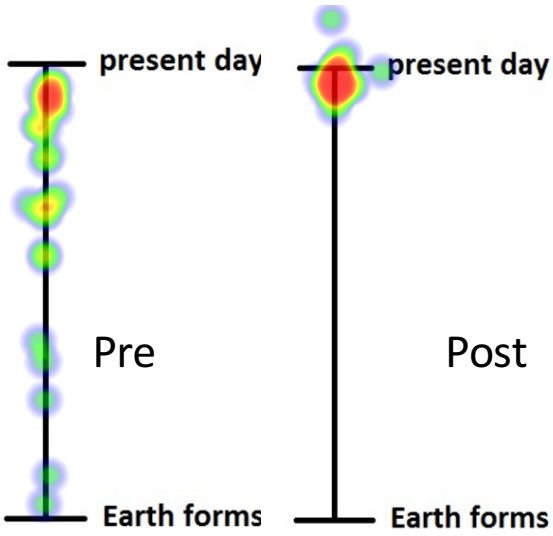
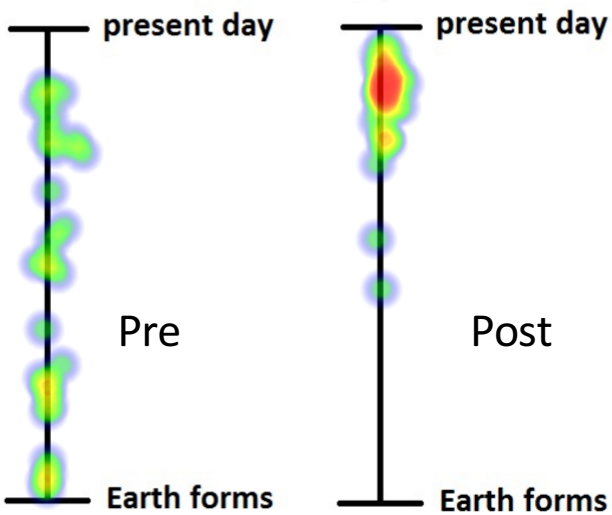
Click where you expect humans appeared



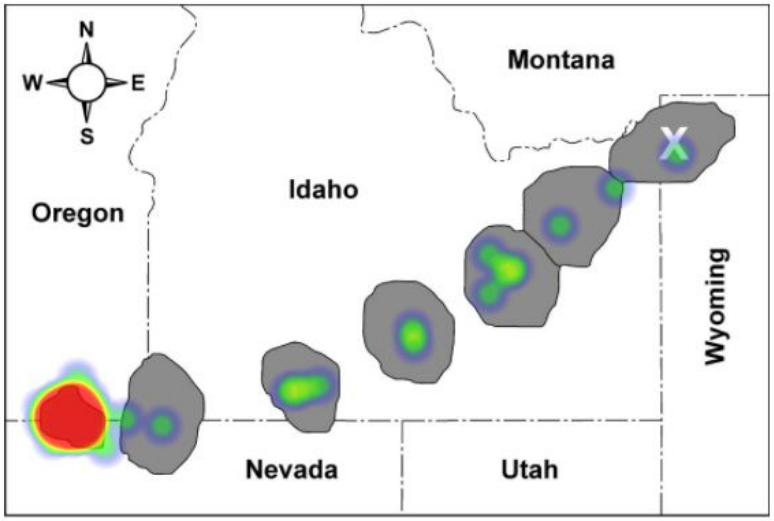
Click where you expect dinosaurs appeared



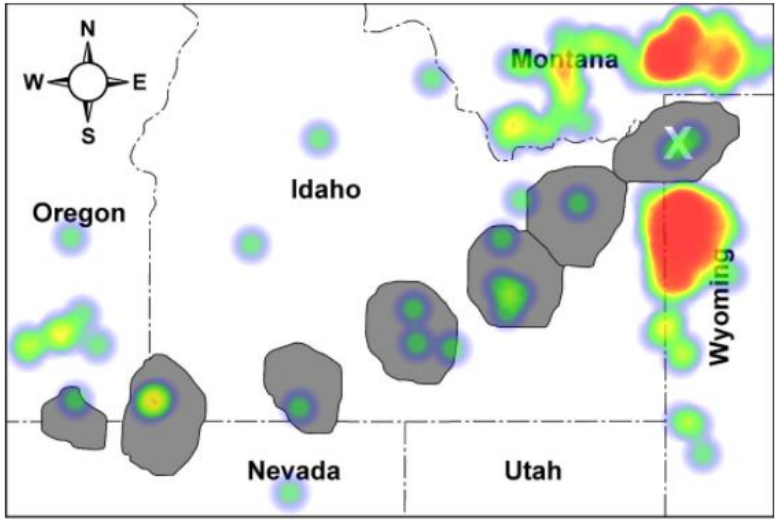
Spatial Reference Frame

Mentally animating the geologic processes forming a static structure

If X is a currently active volcanic caldera, click on the oldest volcanic caldera.

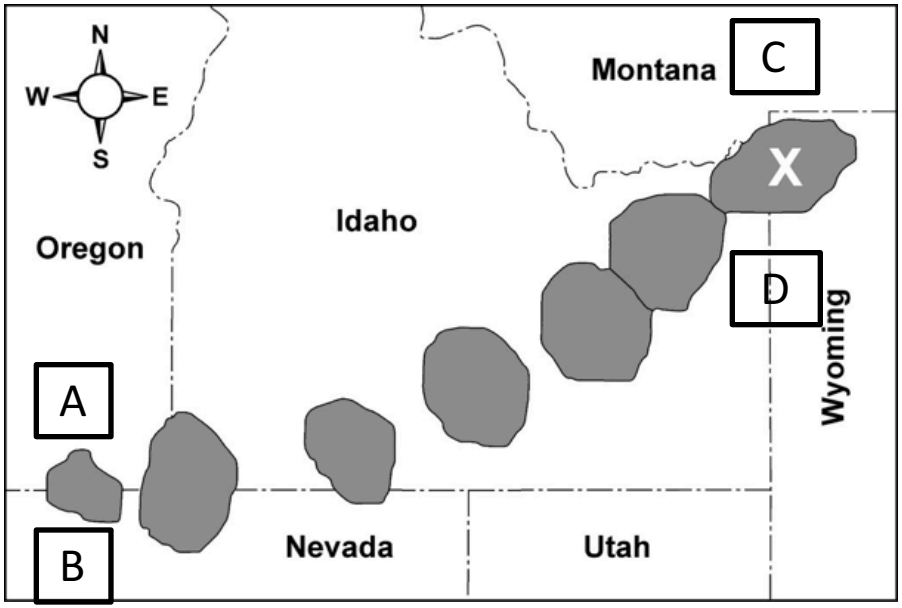


The tectonic plate has moved southwest over this hot spot. If the plate started moving north, click where you expect the next caldera will form.

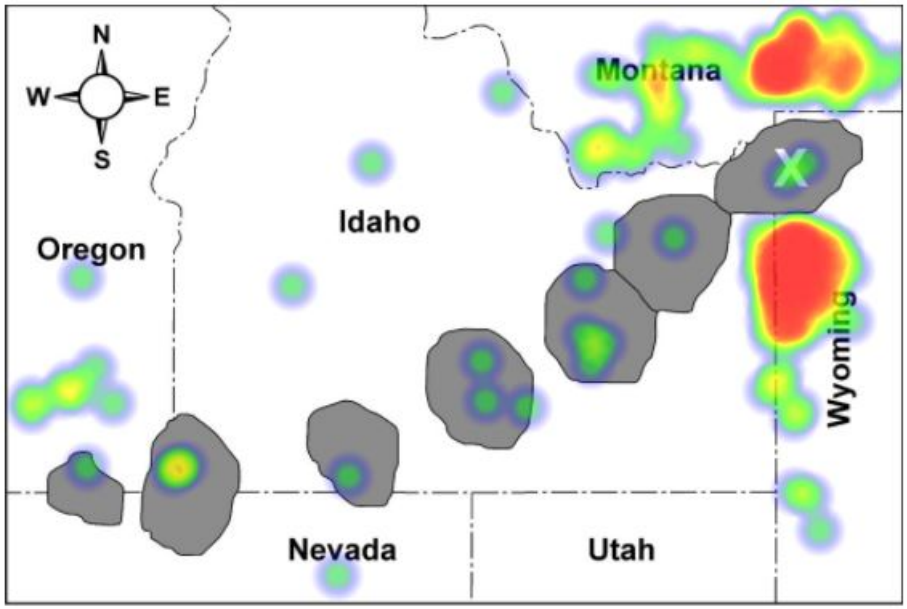


Opportunities

Multiple-Choice



Click-on-Diagram



Suggestions for Developing Questions

Candidate Concepts

- Labeling structures
- Drawing arrows
- Something that changes with respect to space or time

Levels of Questioning

- **Recall**: “click on this feature”
- **Prediction**: “click where you expect…”

Current Inventory of Questions

Earth's Interior	Erosion in stream bed
Faults	Erosion to base level
Isostasy	Longshore Drift
Anticlines/Synclines	Glacial advance/retreat
Dome/Basins	Glacial erosion features
Subduction/melting	Groundwater flow
Plate motion	Differential weathering
Geologic time	Relative dating

Current companies offering CoD questions

CRS Service	Cost	Name of COD Questions
Top Hat	Student	"Click-on-Target"
I-Clicker	Student	"Target Question"
Echo360	Student	"Graphic Response"
Turning Technologies	Student	Available Fall 18 (personal communication, 2018)
PollEverywhere	Instructor	"Clickable Image"
Blackboard	Institution	"Hot Spot Question"
GoFormative	Free	"Show Your Work"

Discussion

In pairs…

- What are some spatial challenges that are difficult for your students? What errors can you count on students making every year?

- Which spatial challenge do you care most about?

Report Out

Present spatial feedback and accommodation activity

- What is the spatial error?
- How are you engaging students in feedback and accommodation?