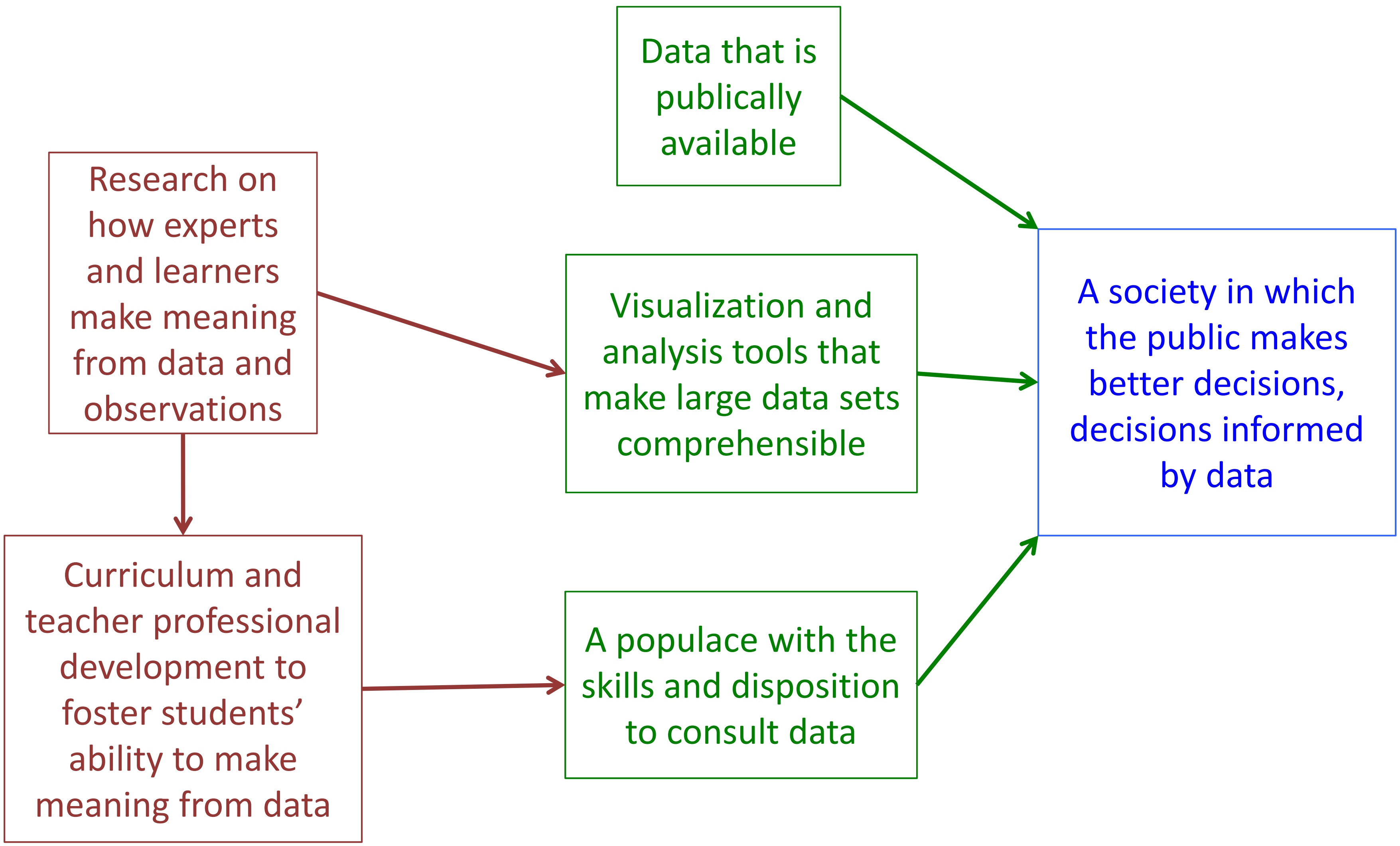
Teaching and Learning with Data

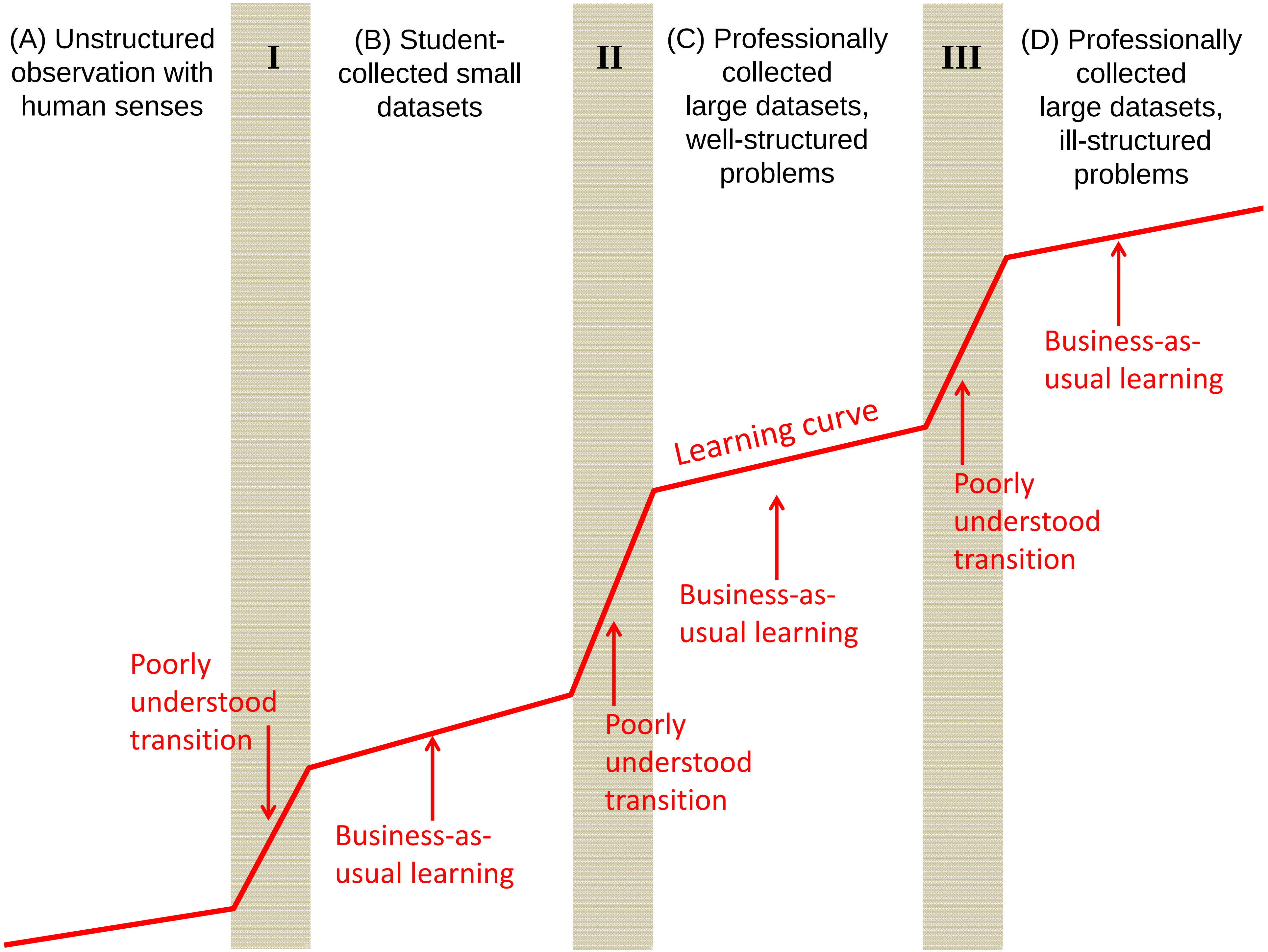
Kim Kastens
Education Development Center, Inc.

Presented at the ESRI Education Conference, San Diego CA
July 6, 2013

EDC OCEANS of DATA INSTITUTE

What's the end goal of teaching with data?




(A) Unstructured observation with human senses
I
(B) Student-collected small datasets
II
(C) Professionally collected large datasets, well-structured problems
III
(D) Professionally collected large datasets, ill-structured problems
Learning curve
Poorly understood transition
Business-as-usual learning
Poorly understood transition
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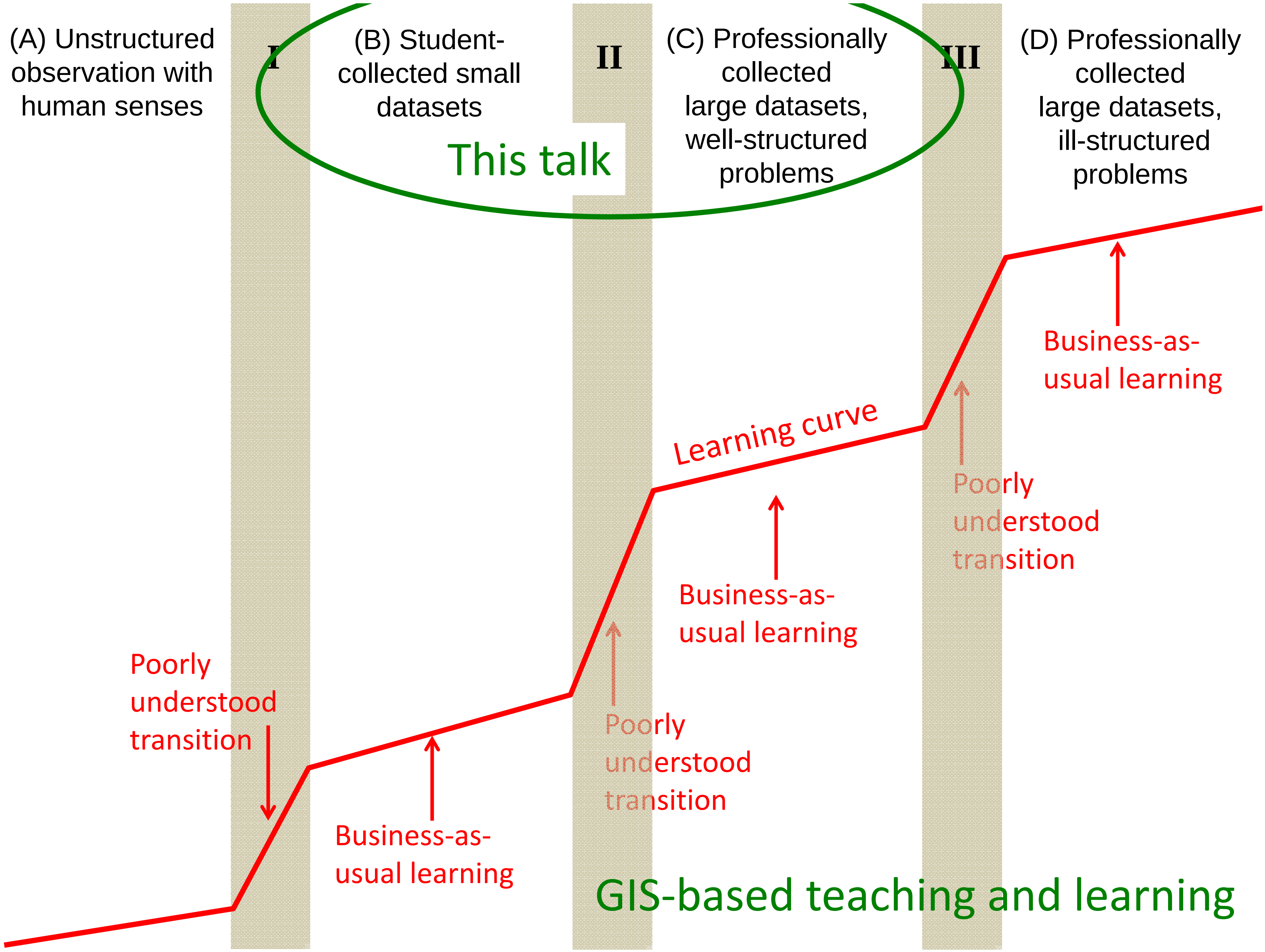

(A) Unstructured observation with human senses
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Business-as-usual learning
Learning curve
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Poorly understood transition
Business-as-usual learning
GIS-based teaching and learning

Why bother with professionally-collected data?

Student-collected data

(from School in the Forest powerpoint,
http://www.blackrockforest.org/docs/about-the-forest/schoolintheforest/)

Professionally-collected data

(from Using a Digital Library to Enhance Earth Science Education,
Rajul Pandya, Holly Devaul, and Mary Marlino)

Why bother with professionally-collected data?

Good choice for phenomena:

- too big
- too far away
- too long in duration
- too expensive
- too dangerous
- too complicated

for student-collected data.

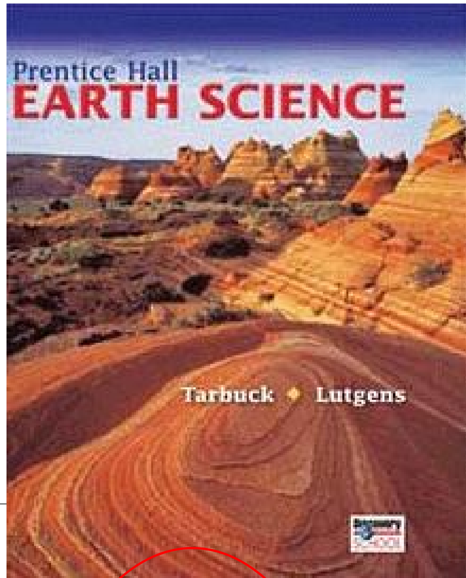
Professionally-collected data

(from Using a Digital Library to Enhance Earth Science Education,
Rajul Pandya, Holly Devaul, and Mary Marlino)

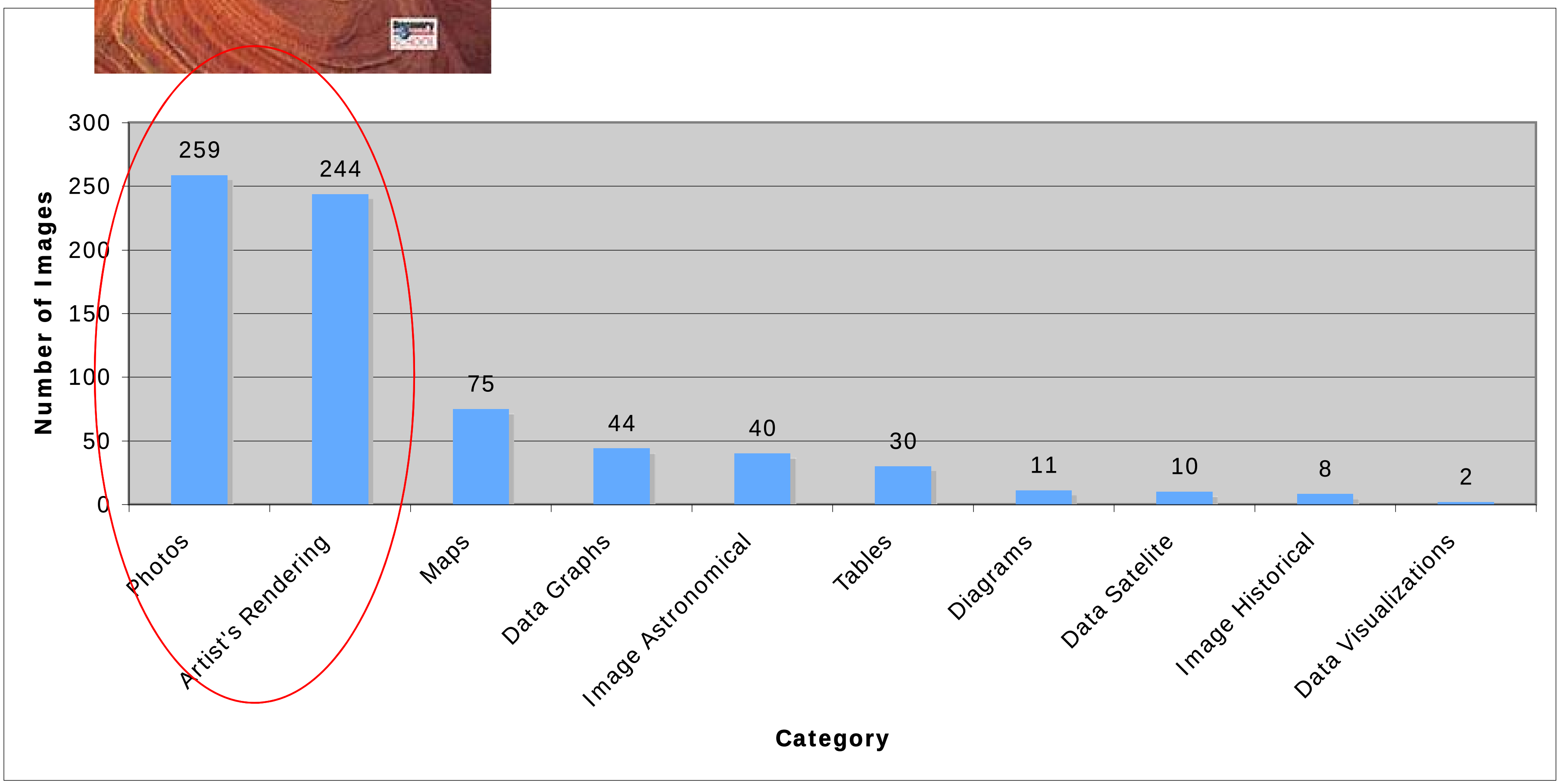
Why bother with professionally-collected data?

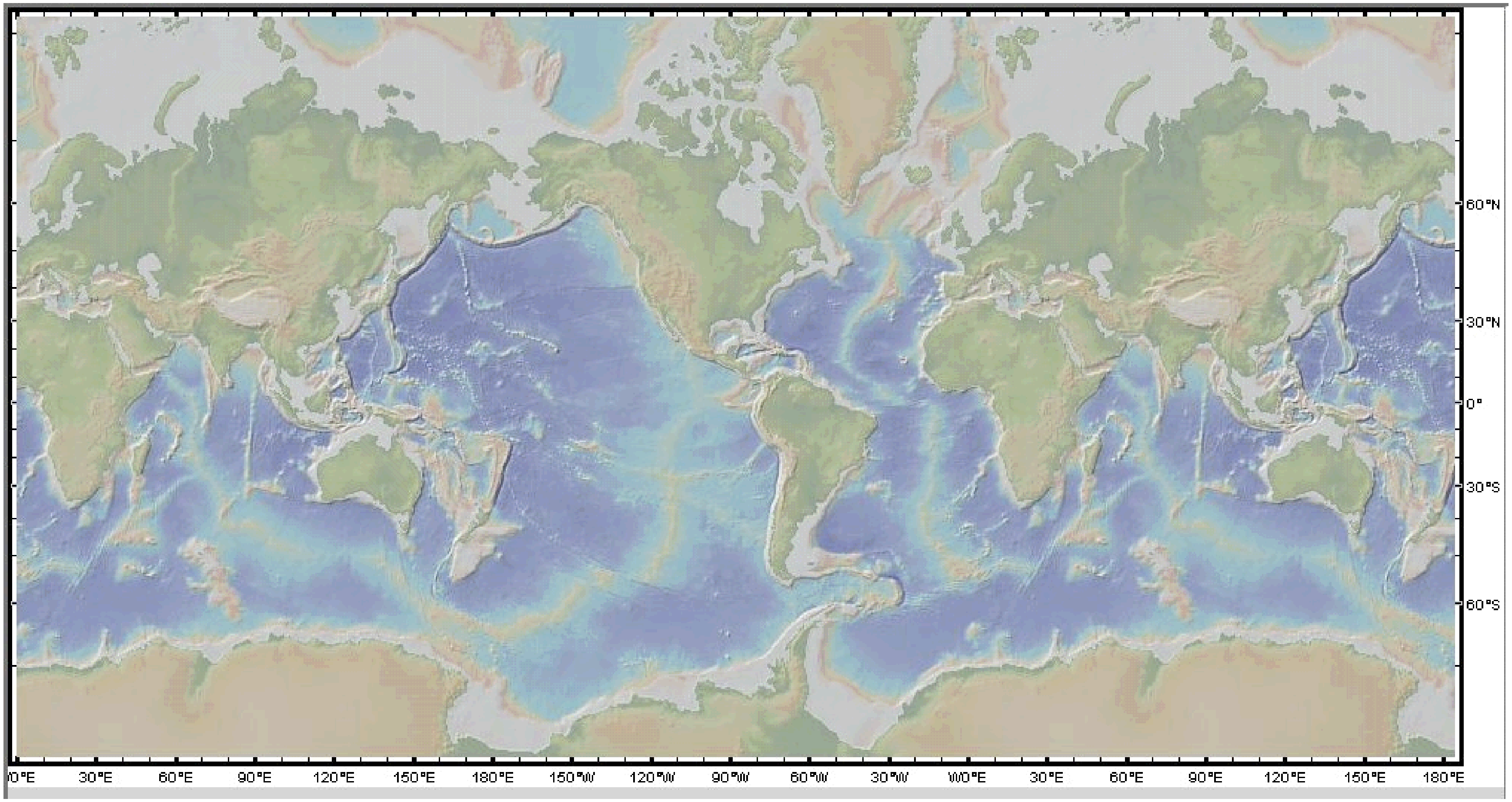
Professionally-collected data

(from Using a Digital Library to Enhance Earth Science Education, Rajul Pandya, Holly Devaul, and Mary Marlino)



Many students have not had very much contact with real data in High School.



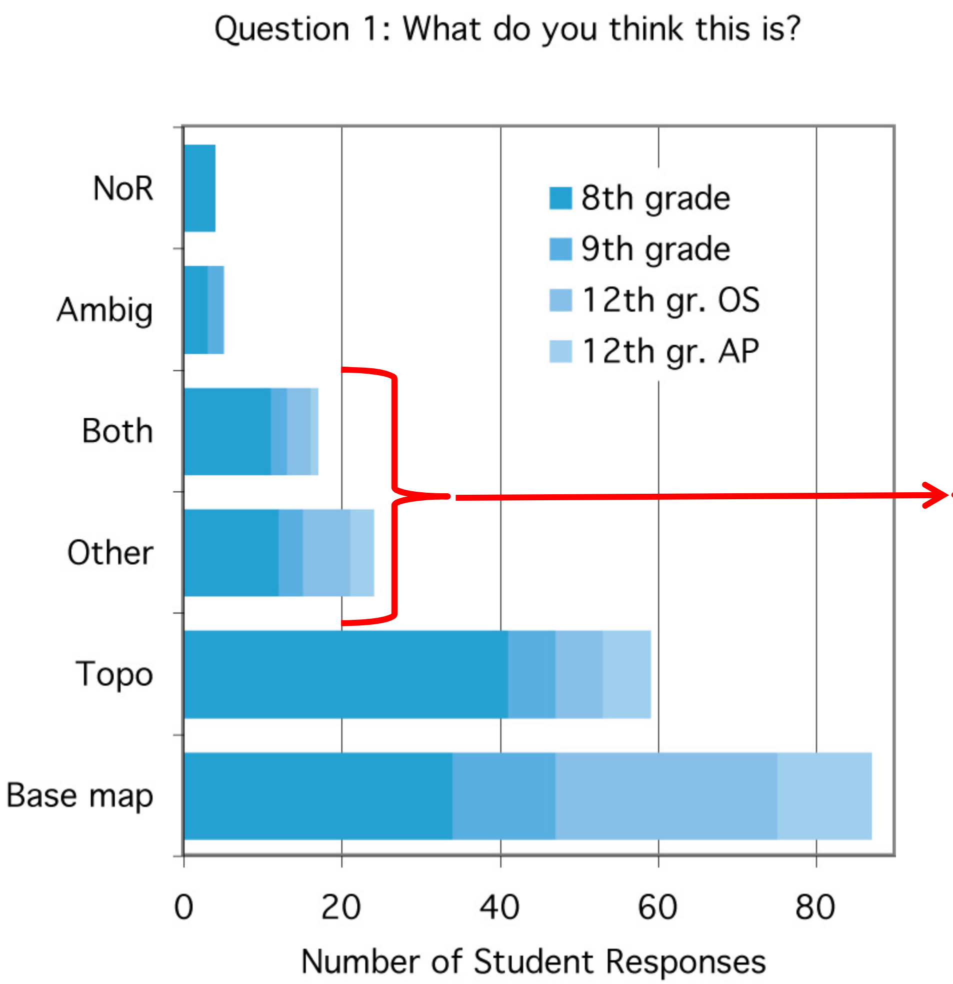


✔(1) What do you think this is?

(2) How do you think this was made?

(3) What do you think this is useful for?

Swenson, S., & Kastens, K. A. (2011). Student Interpretation of a Global Elevation Map: What it is, How it was Made, and What it is Useful for. In A. Feig & A. Stokes (Eds.), *Qualitative Inquiry in Geoscience Education Research* (pp. 189-211): Geological Society of America Special Paper 474.



Examples of "Other"

Fluid Earth:

• "A map of the world showing tides"

• "This is an image of the water temperature for all of earth's oceans"

Solid Earth:

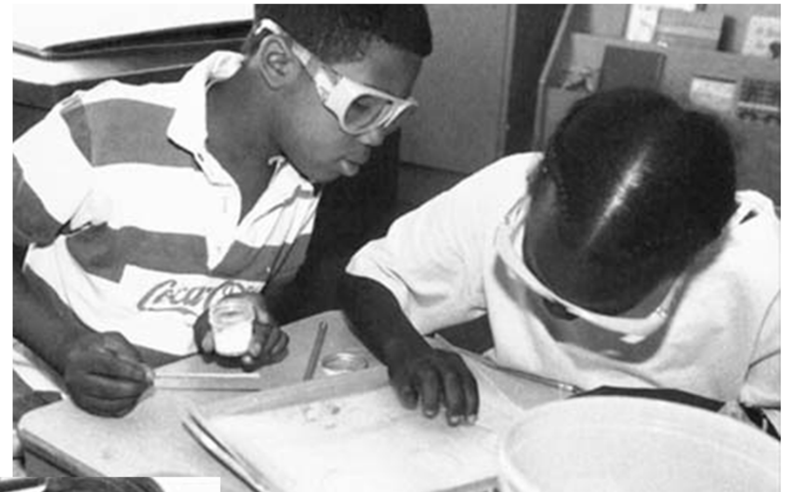
• "A map of the world's plate boundaries and countries."

• "It is a map of the Earth, showing not only topography but sediment deposits as well"

Biology:

"A map of the world that shows vegetation with green and either desert or tundra with off white."

Most data experiences have been with small, student-collected data sets

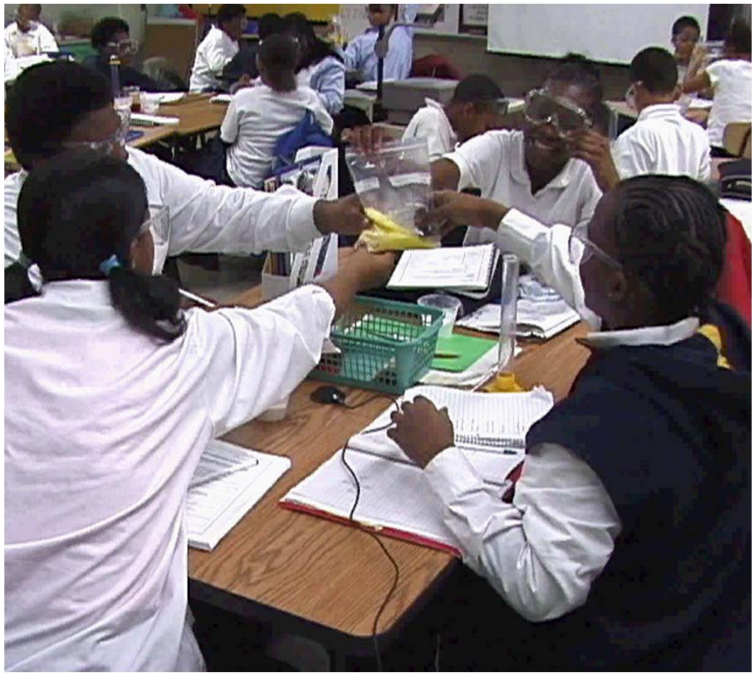


Chapter 6
Science Content Standards

Student-collected data versus other-collected data

Hug, B. and K.L. McNeill (2008) Use of first-hand and second-hand data in science: Does data type influence classroom conversations?, *International Journal of Science Education*.

IQWST Biology & Chemistry units



Both first and second hand data spurred discussion of:

- “ownership of data” i.e. where data came from
- how data provide evidence for claims/interpretation/conclusion
- patterns in data
- use of course content in discussing/explaining data

Only first hand data spurred discussion of limitations of data:

- how errors could have come during process of setting up the experiment
- how errors could have come in during making the measurement

What is involved in this transition?

Student-collected data

Professionally-collected data

Day in the Life of the Hudson

Kim aboard *Joides Resolution*, Leg 107

Elements of a Learning Progression ….

Embodied, experiential grasp of the natural setting and data collection methods

Metadata

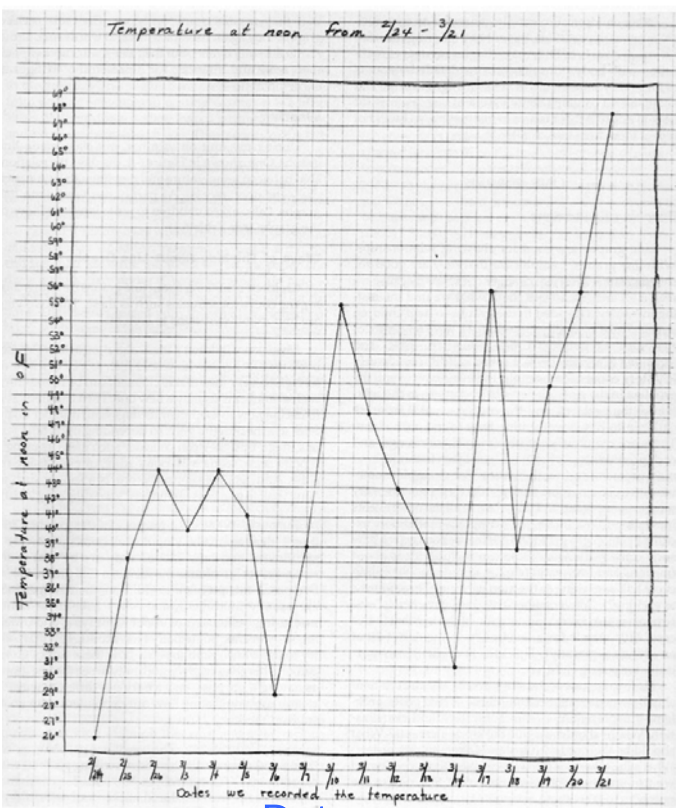
(from School in the Forest powerpoint, http://www.blackrockforest.org/docs/about-the-forest/schoolintheforest/)

(from Using a Digital Library to Enhance Earth Science Education, Rajul Pandya, Holly Devaul, and Mary Marlino)

Elements of a Learning Progression ….

Dozens of data points

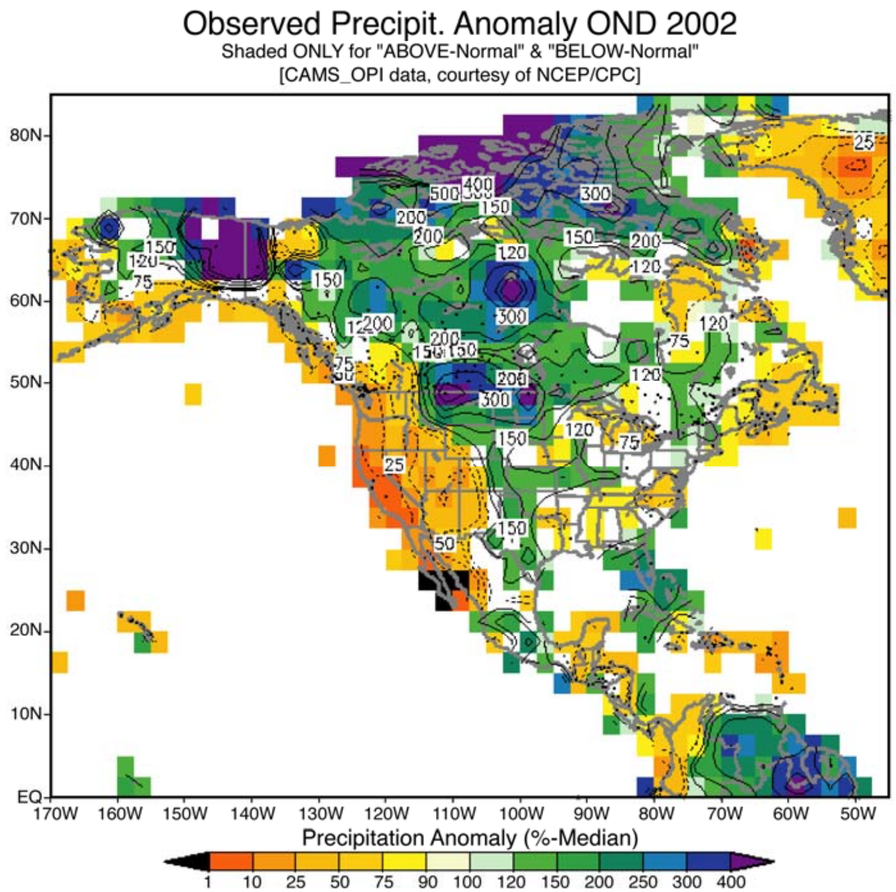
Megabytes



Air temperature at noon

Date

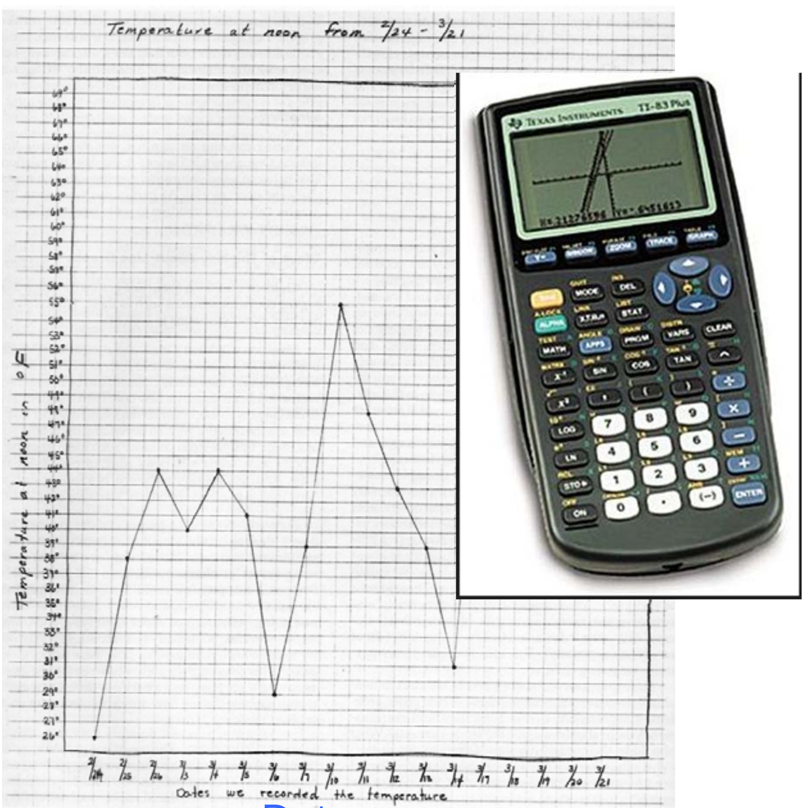
(from Clement, 2002)



Simple, transparent tools and techniques

Sophisticated tools & techniques

Air temperature at noon



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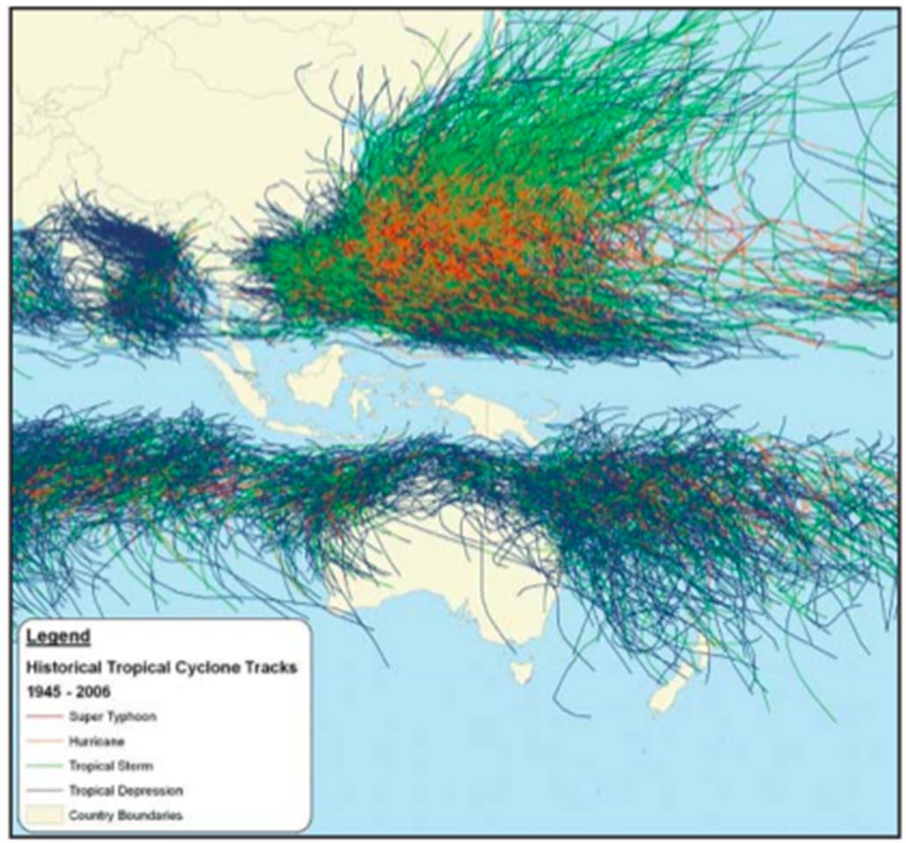


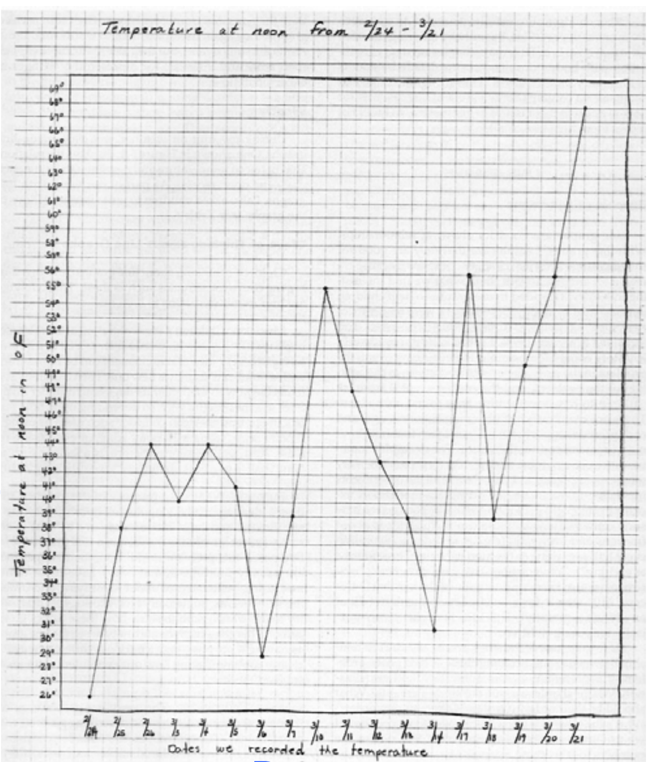
http://www.esri.com/library/ebooks/climate-change.pdf

Elements of a Learning Progression ….

Interpret one data set at a time

Multiple data sets with interactions; varying data types

Air temperature at noon



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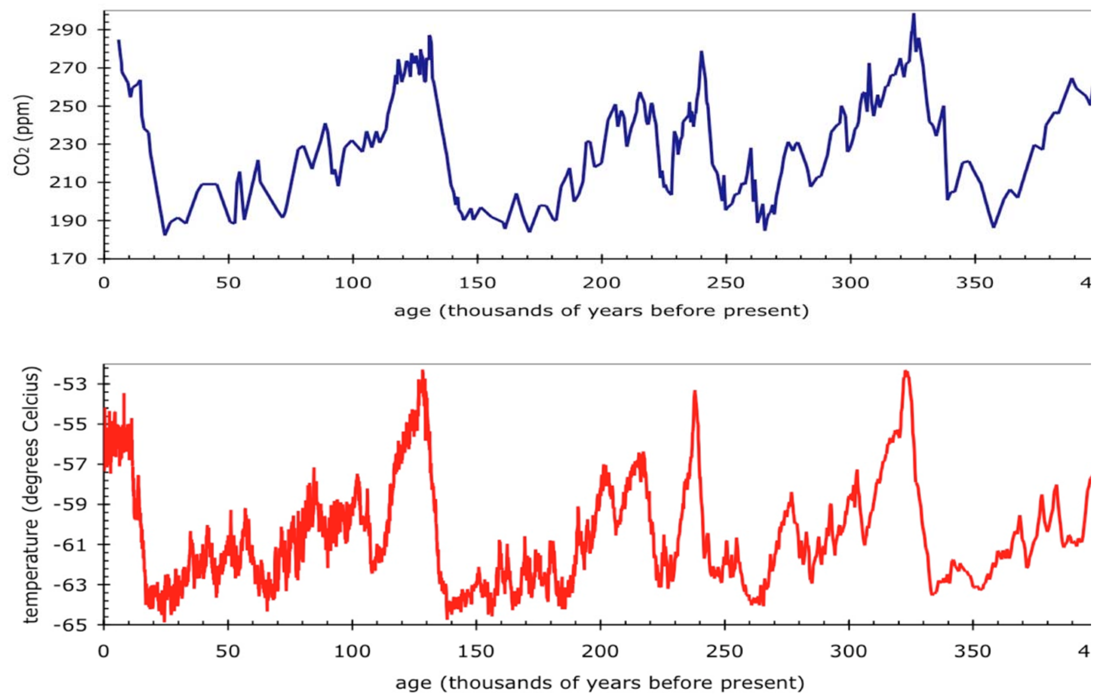
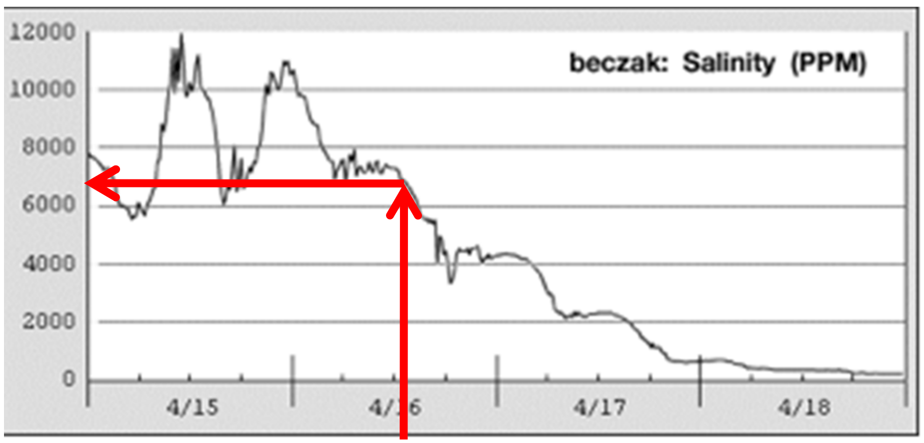


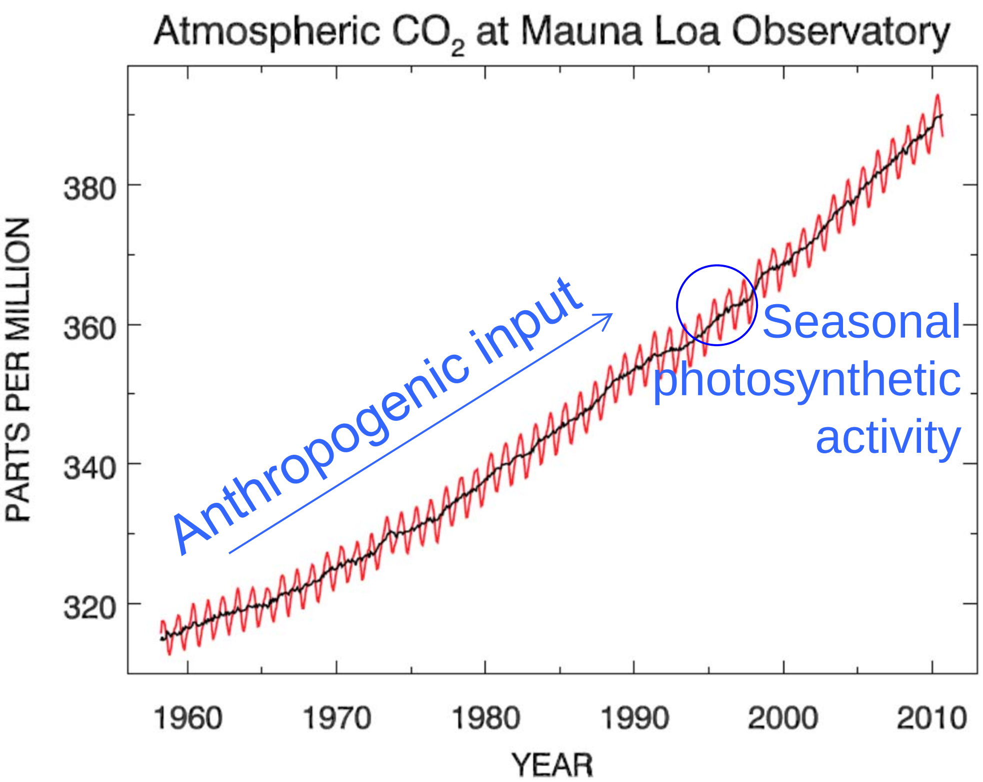
Elements of a Learning Progression ….

Looking up values

Seeing and interpreting patterns



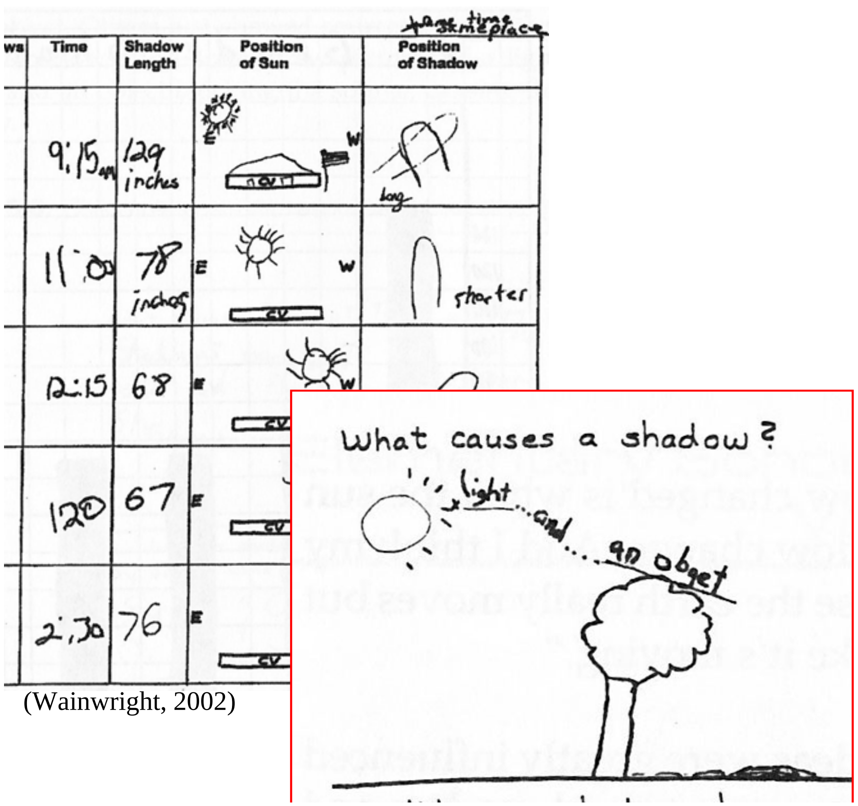
What was the salinity at noon on April 16?



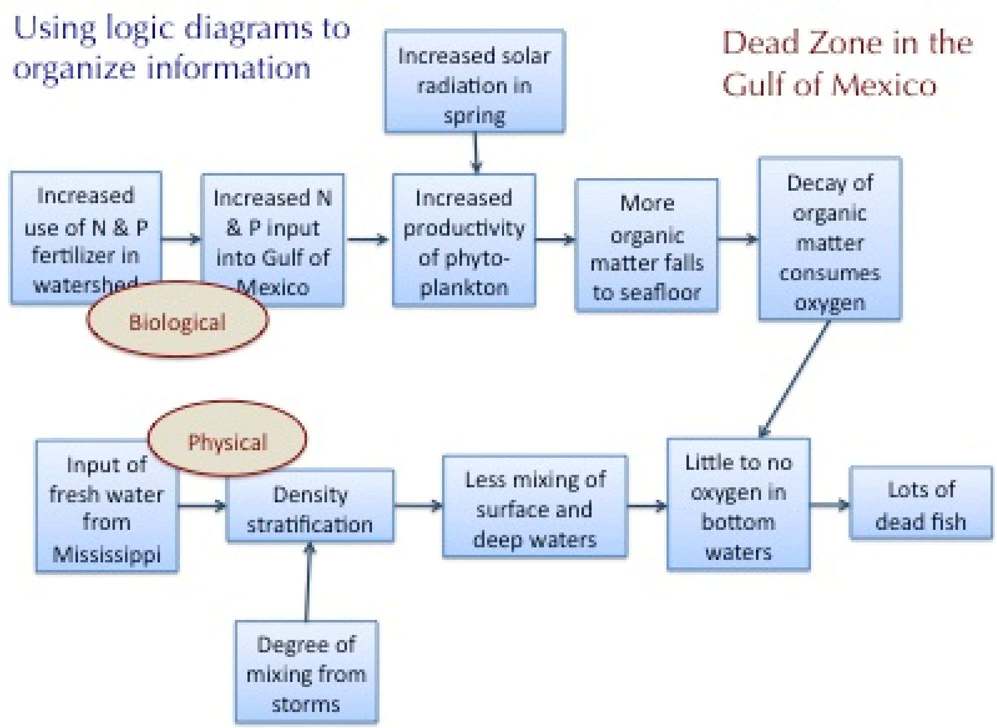
Elements of a Learning Progression ….

Common sense lines of reasoning

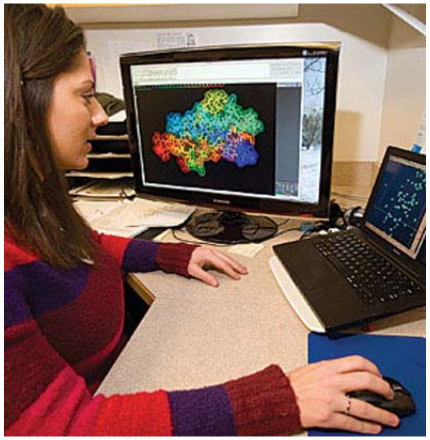
Spatial, temporal, statistical reasoning. Multi-step chains of reasoning



(Wainwright, 2002)



Day in the Life of the Hudson



http://www.umt.edu/urelations/rview/winter10/briknarova.html

• Student-collected data	• Professionally-collected data
• Embodied, experiential sense of circumstances	• Sense of circumstances from metadata
• Dozens to hundreds of data points	• Megabytes
• Simple, transparent tools & techniques	• Complex tools & techniques; black boxes
• Interpret one data set at a time	• Multiple data sets and their interactions
• "Common sense" lines of reasoning	• Temporal, spatial, quantitative and other lines of reasoning
• Single step causal chains	• Multi-step lines of reasoning

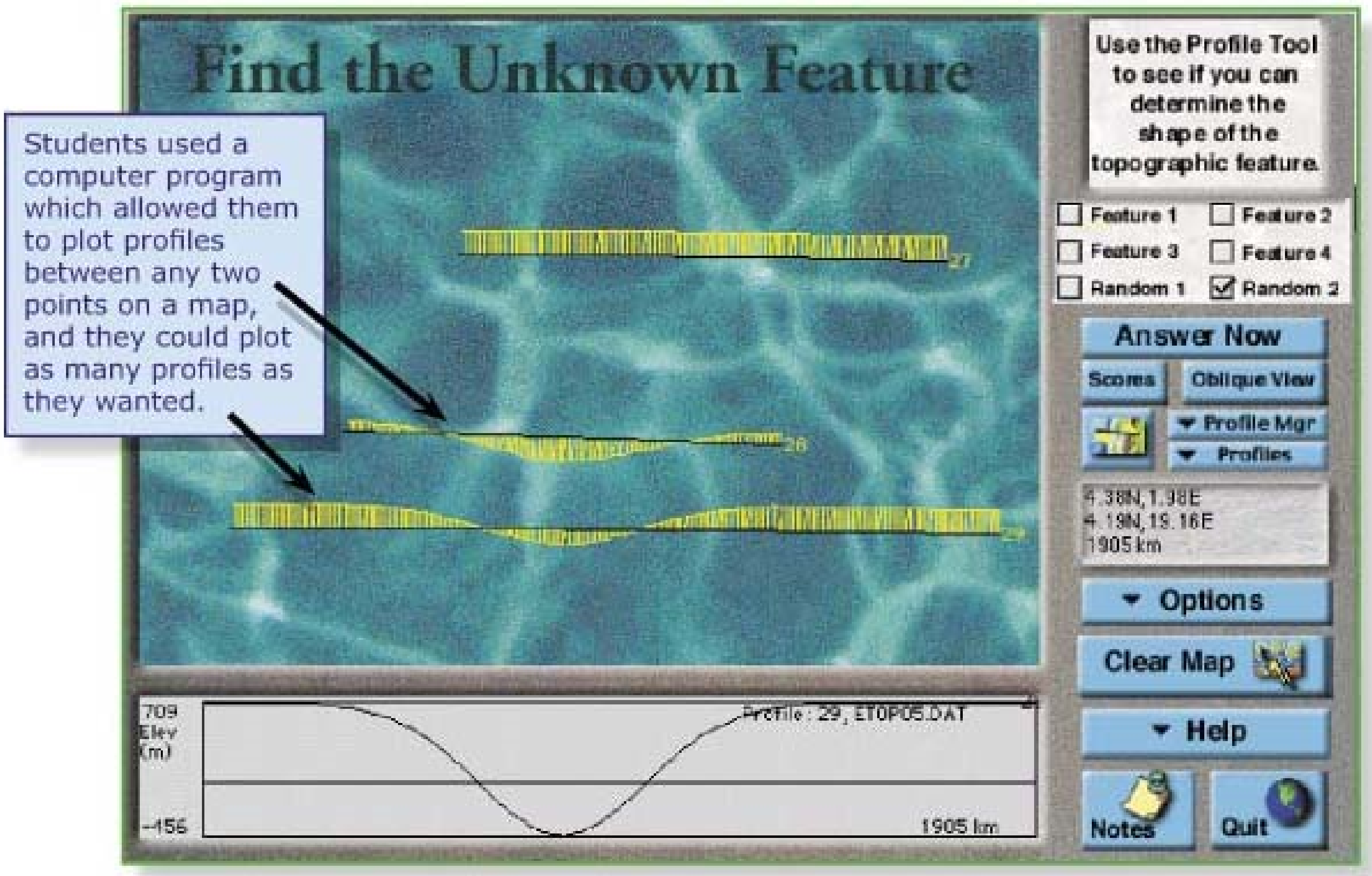
Two ways to scaffold students' transition from small, student-collected datasets to large, professionally-collected data bases

(1) Provide a hypothesis array or choice array

(2) Hybrid activities in which student-collected data are embedded within professionally-collected data

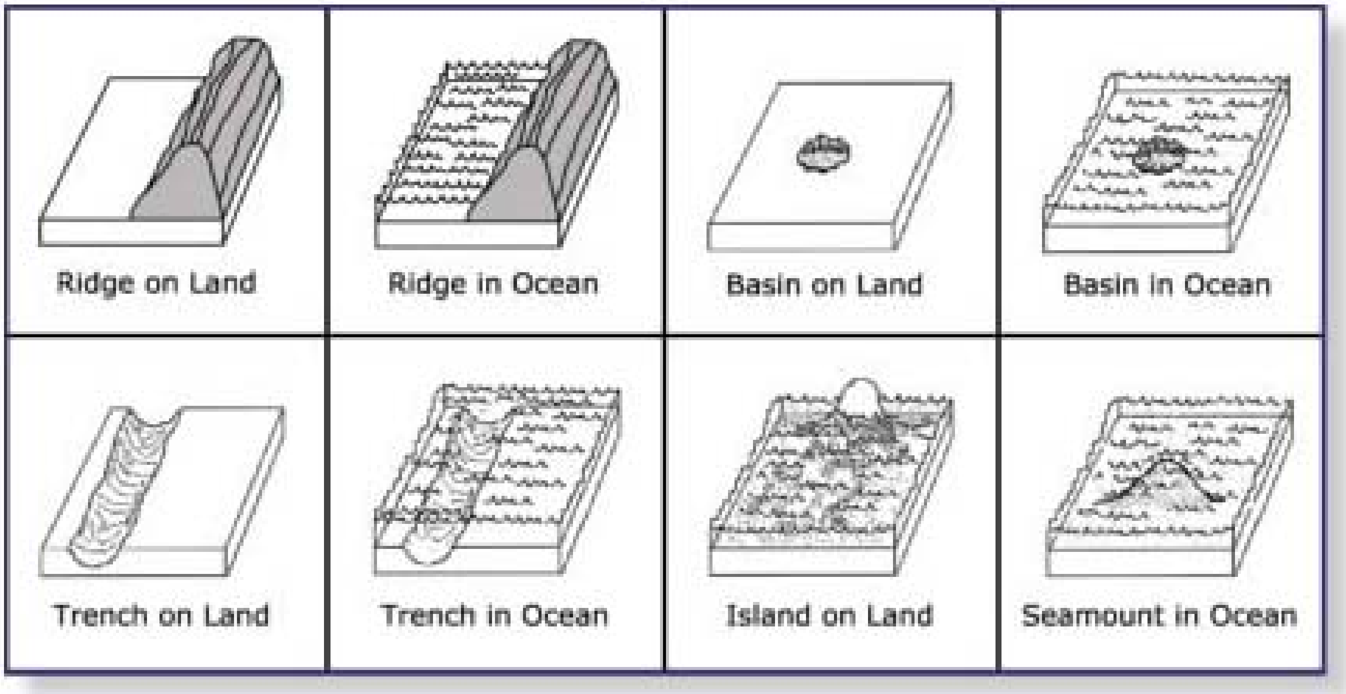
Hypothesis: scaffold data exploration by providing a choice array.

"You are a geologist looking down onto an area of land or ocean which is hidden from view. You need to find out which ONE of these geological features—island, ridge, trench, basin or seamount—is hidden below you."
The geological features were defined.



(from Mayer, 2002, based on software by W. Prothero)

First Training Approach: Look at sketches of possible geological features: “Pictorial Training”

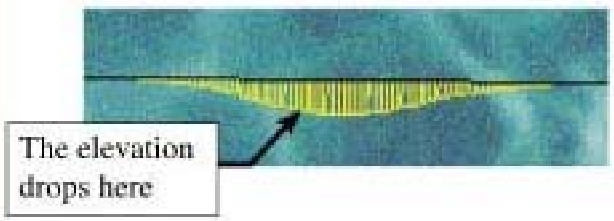


(after Mayer et al, 2002)

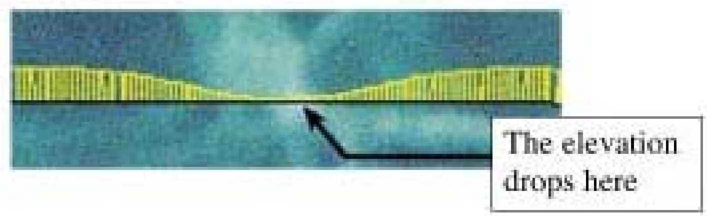
Second training approach: "Strategic Scaffolding"

Profile Game Strategy

- First, I would draw a few long profile lines to get a general overview of the area.
- I would then look for a change in elevation in any of the profile lines. If the lines are relatively flat (don't show bumps or dips), that means the earth below the line is flat.
- If I see the profile line show **a drop in elevation**, like:



or



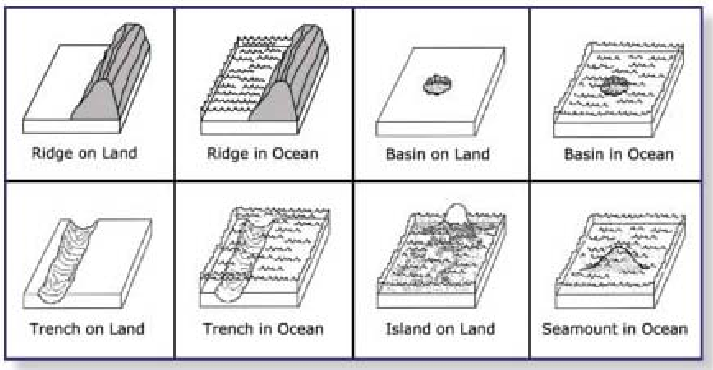
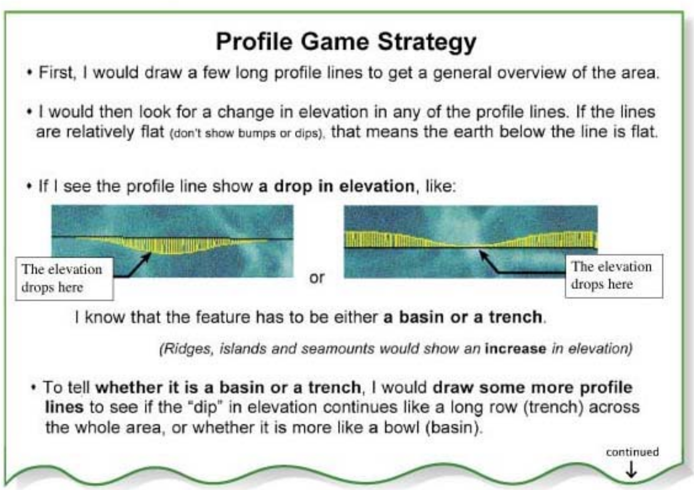
I know that the feature has to be either **a basin or a trench**.

(Ridges, islands and seamounts would show an **increase** *in elevation)*

- To tell **whether it is a basin or a trench**, I would **draw some more profile lines** to see if the "dip" in elevation continues like a long row (trench) across the whole area, or whether it is more like a bowl (basin).

continued ↓

(after Mayer et al, 2002)

<table>
<tr><td></td><td>Correct answers out of 5:</td></tr>
<tr><td>Control (no aids)</td><td>M=2.36 SD=1.52</td></tr>
<tr><td>
</td><td>M=3.25 SD=1.41</td></tr>
<tr><td>
</td><td>M=2.90 SD=1.78</td></tr>
<tr><td>Both aids</td><td>M=3.39 SD=1.41</td></tr>
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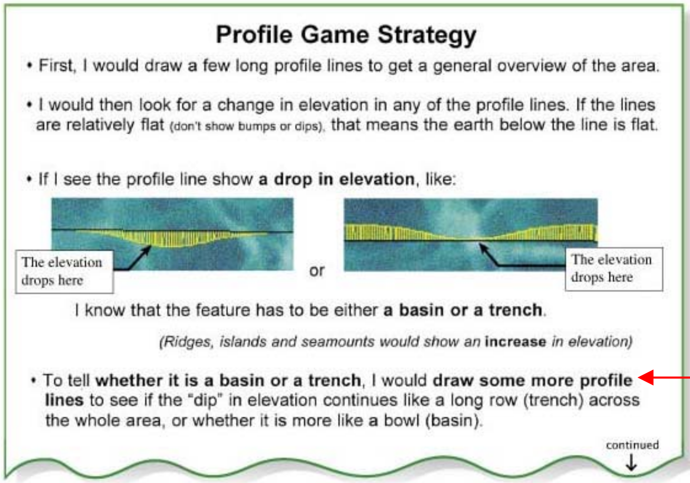

Profile Game Strategy

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- I would then look for a change in elevation in any of the profile lines. If the lines are relatively flat (don't show bumps or dips), that means the earth below the line is flat.
- If I see the profile line show a **drop in elevation**, like:

The elevation drops here

or

The elevation drops here

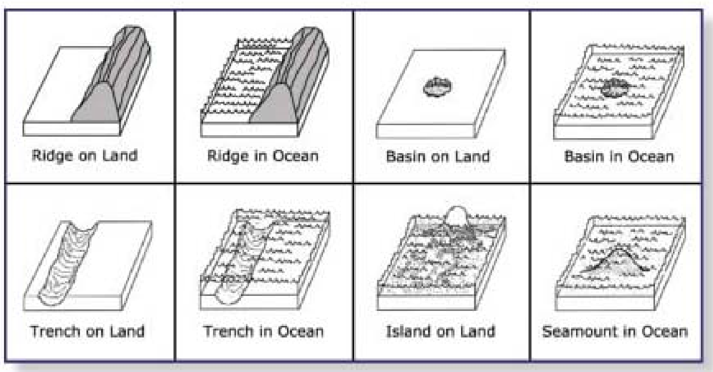
I know that the feature has to be either **a basin or a trench**.

(Ridges, islands and seamounts would show an ***increase*** *in elevation)*

- To tell **whether it is a basin or a trench**, I would **draw some more profile lines** to see if the "dip" in elevation continues like a long row (trench) across the whole area, or whether it is more like a bowl (basin).

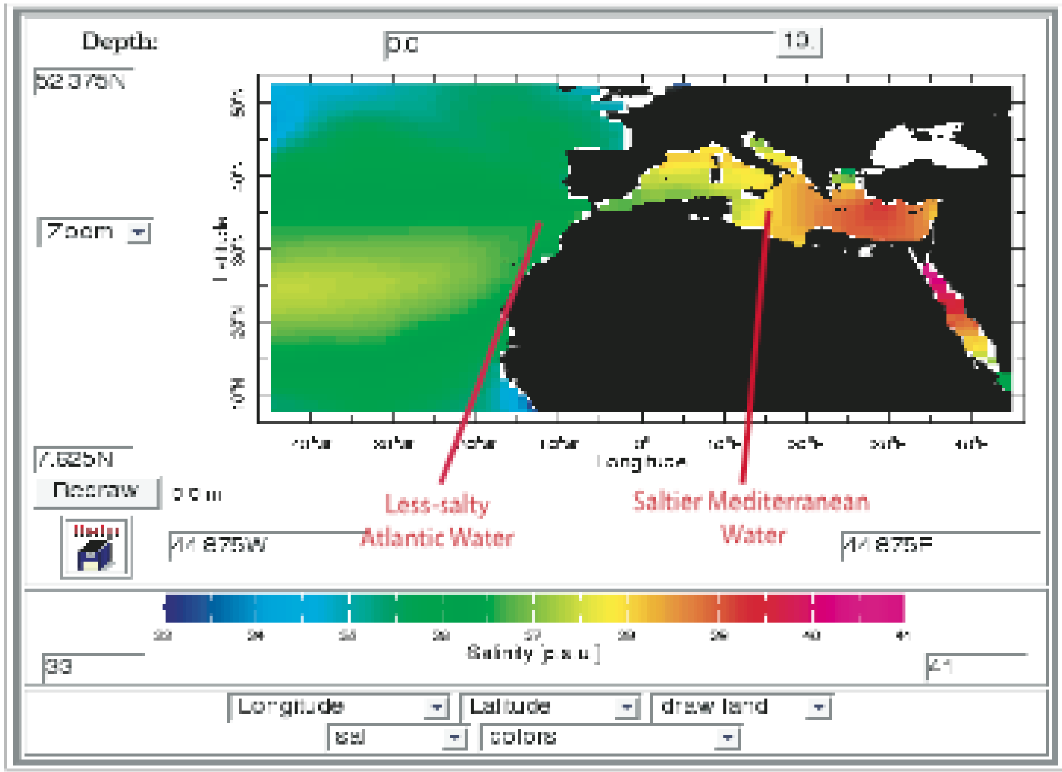
continued ↓

Analyzing and clearly articulating the strategies used by experts…..



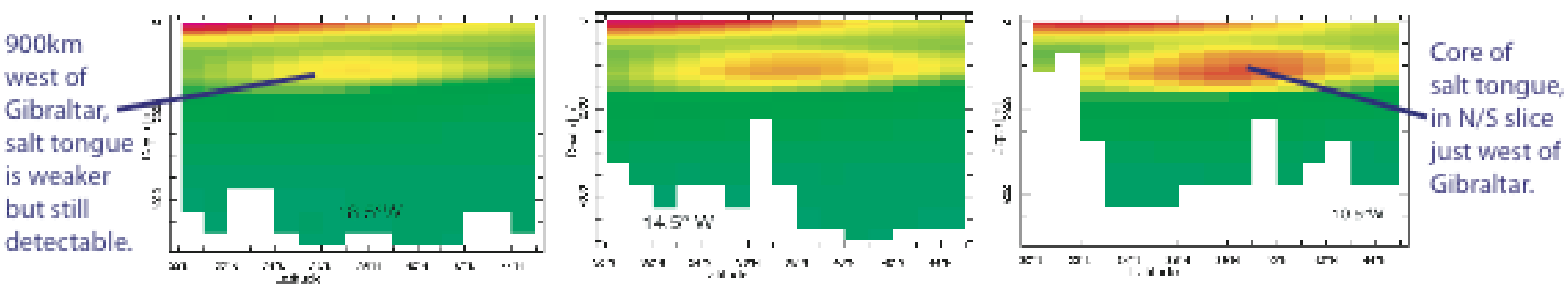
…. was not as valuable as providing a visual array of candidate answers.

Choice array supported methodical reasoning from observations.
Could we generalize this insight to other kinds of data and observations?



In “Planet Earth” class, students explore a data set of ocean temperature and salinity, with a data viewer that lets them make any N-S, E-W or horizontal slice, and zoom or pan at will.

They are supposed to “discover” the Mediterranean salt tongue.



Existing Scaffolding

Go to http://www.ldeo.columbia.edu/dees/ees/
Click “Data”
Click “Oceanographic”
Select “Annual: LEVITUS Salinity”
Click anywhere on the map. The control buttons should appear around the map.

This will bring you a view of the salinity of the world ocean, as shown on the Lamont Data Viewer.

(1) You can zoom in or out by using the “zoom” pulldown menu and clicking “redraw. ”   For example "x4" zoom brings you to a view that is four times as detailed as the previous view.   Zoom in the region of the Mediterranean and eastern North Atlantic.

(2) The colors show the salinity of the water according the scale beneath the map.   What is the maximum salinity in the Mediterranean and eastern Atlantic? What is the minimum salinity? *(Show units.)*

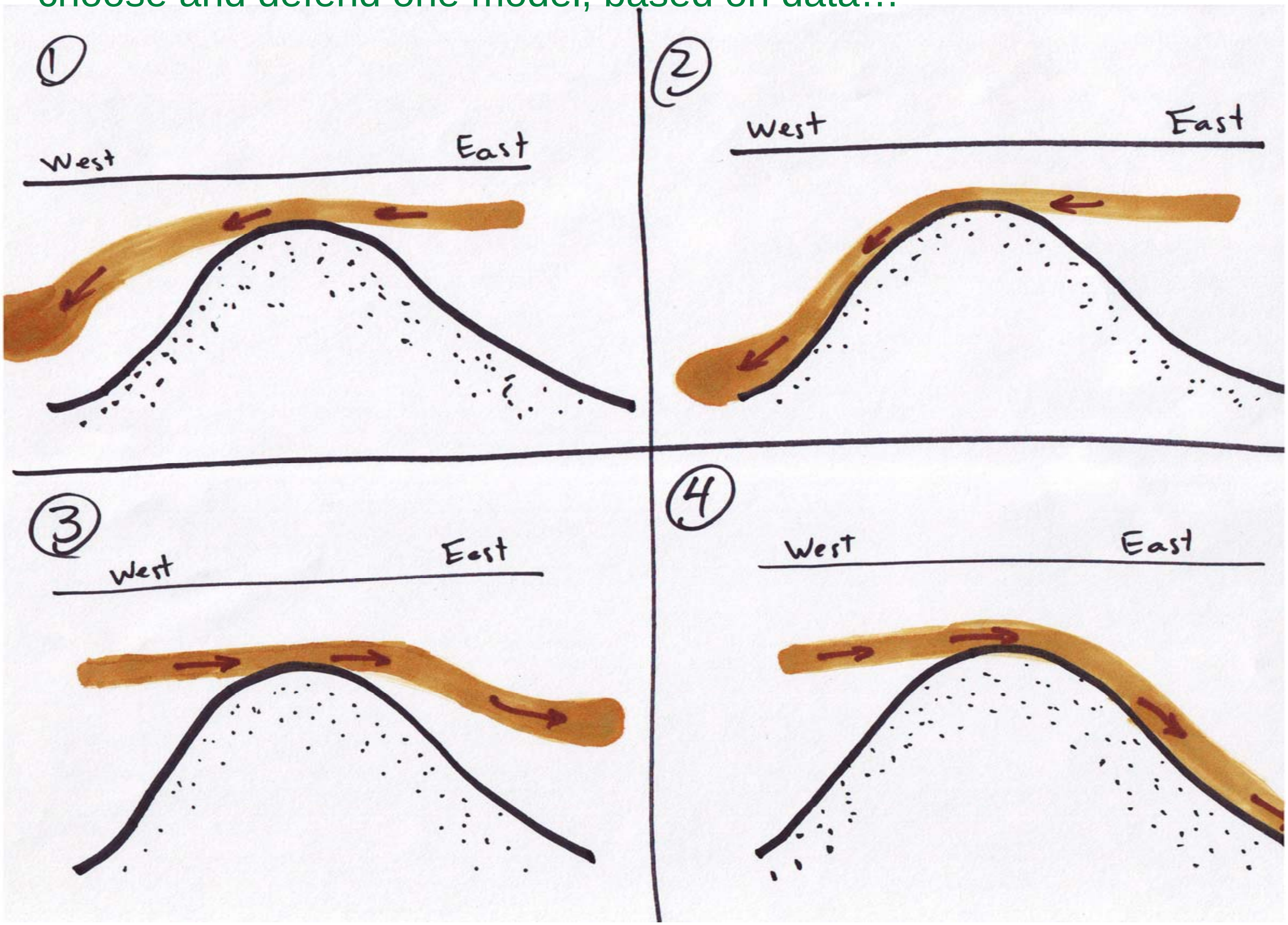
….. Snip….

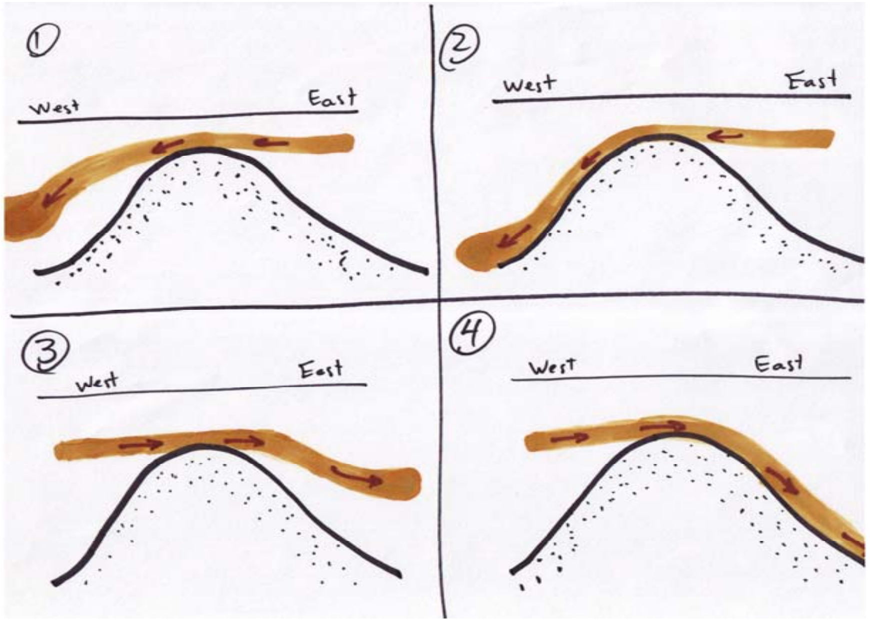
(4) Initially the display shows the salinity of the water at the surface of the ocean (0m depth). You can change the depth of the display by typing a new number in the space above the map and clicking “Redraw.”   Use the depth controls to scroll down through the water column in 100m increments. Observe how salinity varies with depth in the region near the Straits of Gibraltar. Write your observations below:

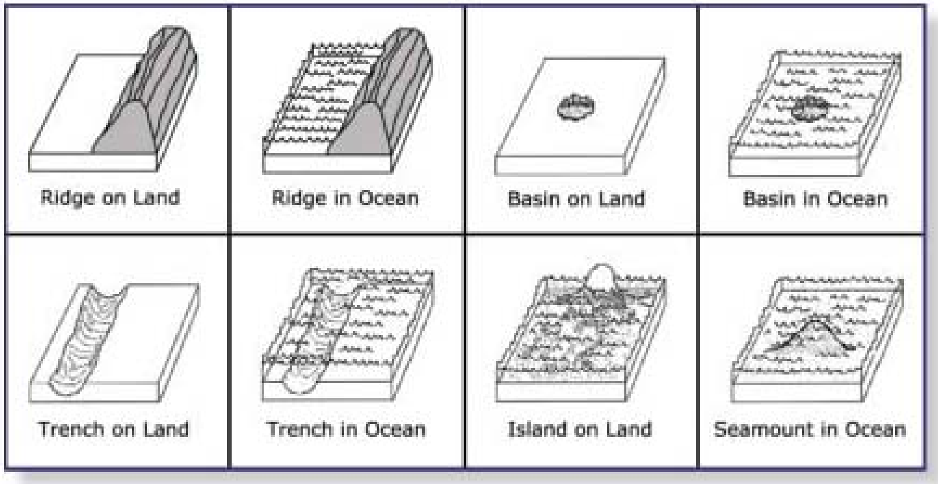
Would a choice array be better scaffolding?

An array of spatial hypotheses:

choose and defend one model, based on data…







Cartoon-like sketches may more nearly approximate our mental images than would polished renderings.

Answer should not be guessable in advance from “textbook learning.”

Structure requires commitment; no vague waffling.

Two ways to scaffold students' transition from small, student-collected datasets to large, professionally-collected data bases

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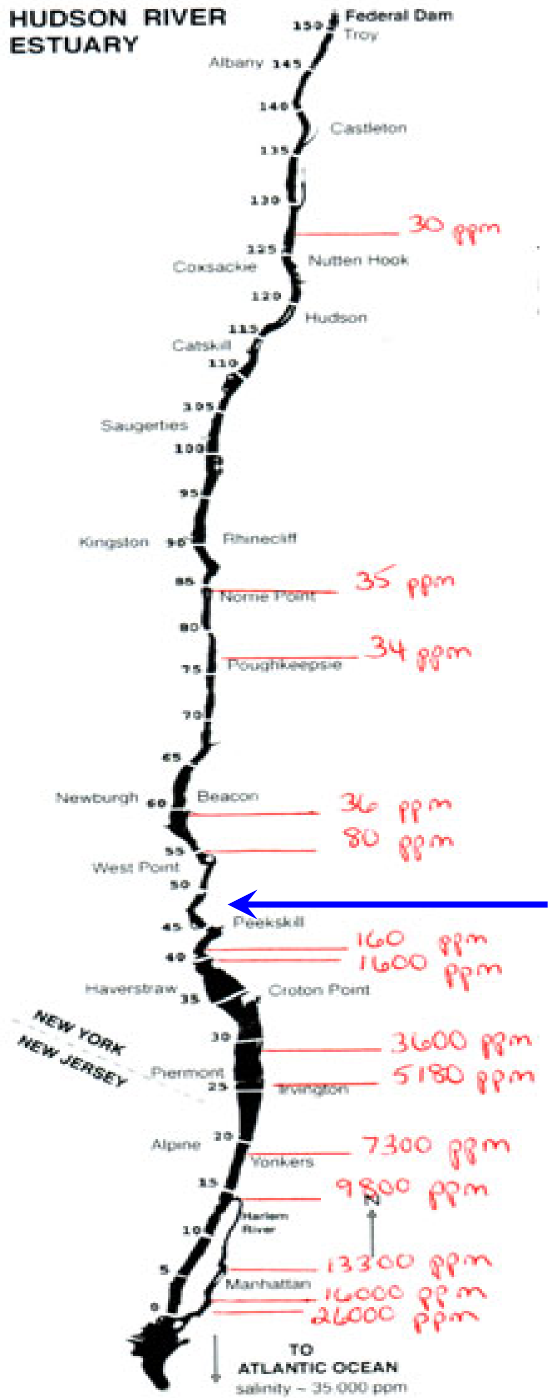
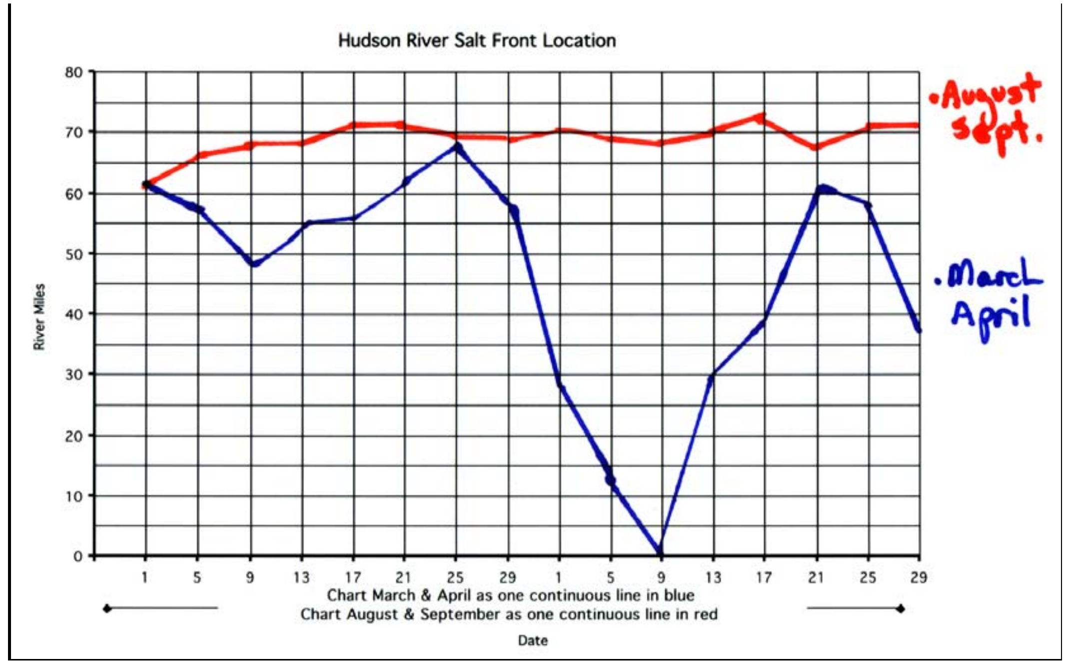
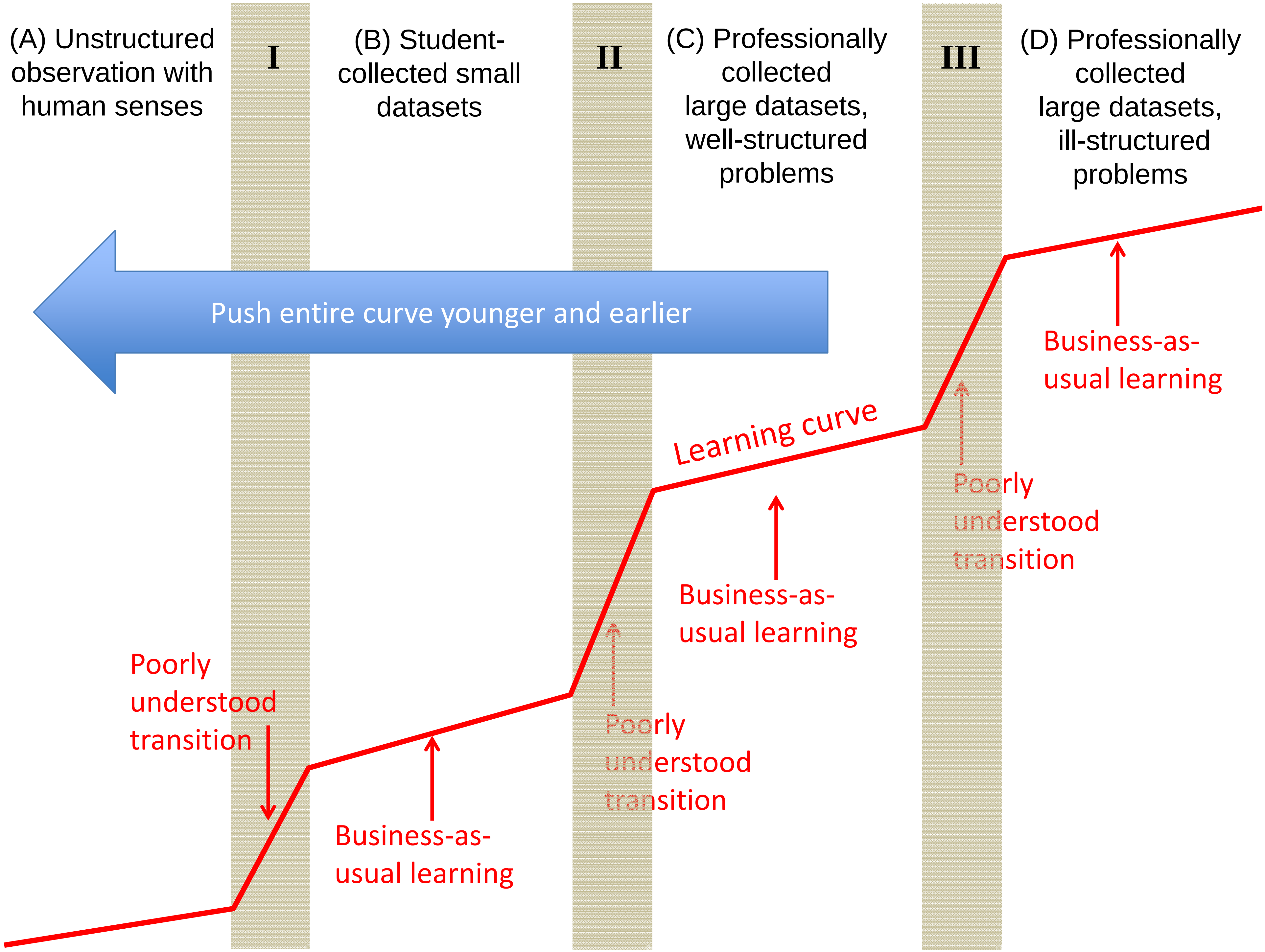
'A Day in the Life of the Hudson River' is looking forward to our next event October 10th, 2013!



“Salt Front” at 100ppm



Turrin, M., & Kastens, K. A. (2010). Is the Hudson River too salty to drink? . In K. A. Kastens & M. Turrin (Eds.), *Earth Science Puzzles: Making Meaning from Data* (pp. 186). Washington, D.C.: National Science Teachers Association.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Push entire curve younger and earlier
Learning curve
Poorly understood transition
Business-as-usual learning
Poorly understood transition
Business-as-usual learning
Poorly understood transition
Business-as-usual learning

How young can we push Transition II?

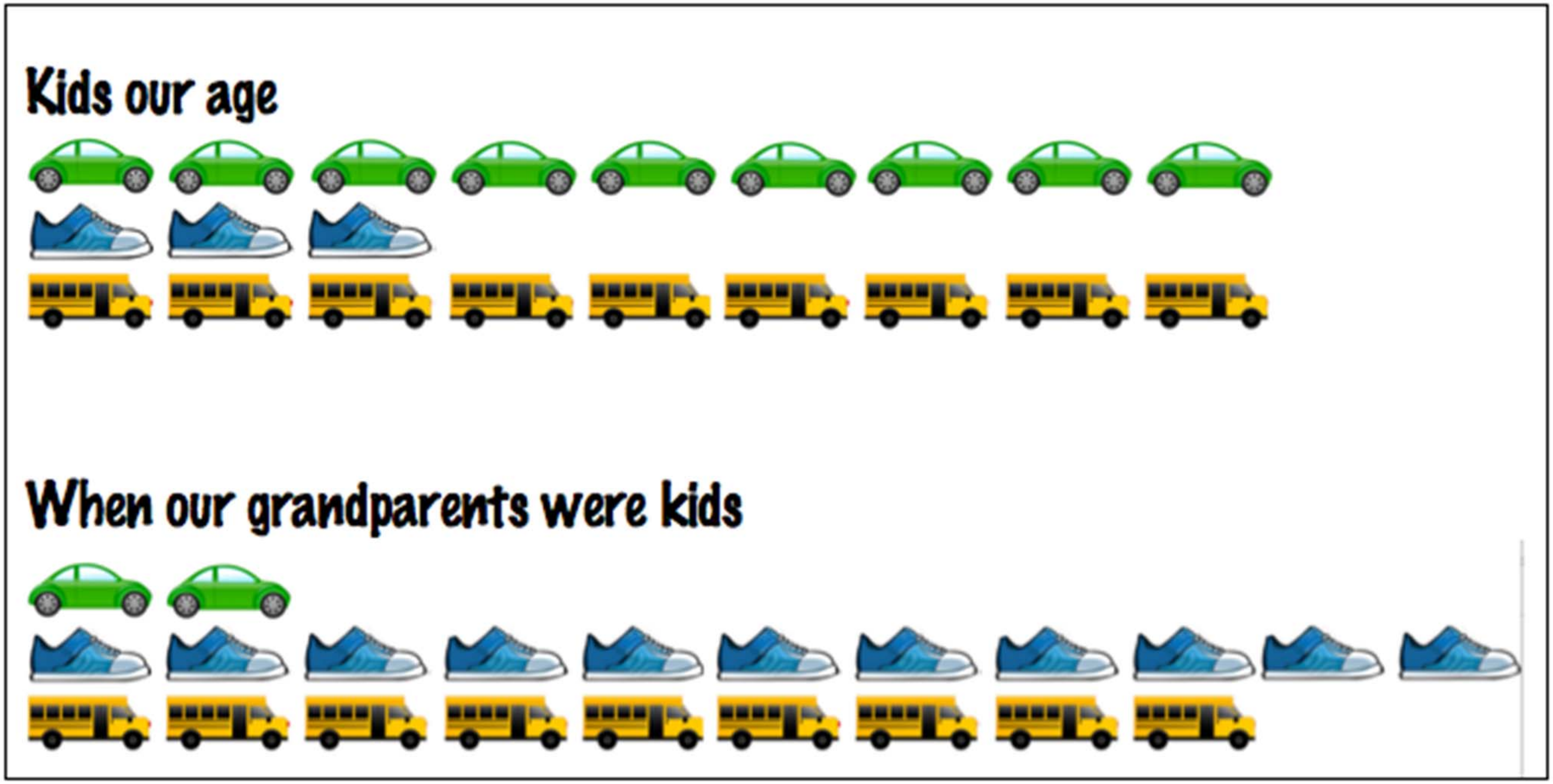
A kid who comes to school by car

A kid who walks to school

A kid who comes to school by schoolbus

- Number of students that walked to school ___________
- More students _________ than __________ to school.
- How many more children take the bus to school than walk to school? __________

Adapted from:
• Bright Hub Education: http://www.brighthubeducation.com/elementary-school-activities/6497-transportation-graph-lesson/#imgn_1
• Eduplace: http://www.eduplace.com/math/mthexp/g2/challenge/pdf/cm_g2_4_8.pdf



- What has changed in how kids get to school since our grandparents were kids?
- What possible explanations could there be for this change?
- How could we figure out which of these explanations is true?

Professionally-collected data on this same topic:

National Center on Safe Routes to School. (2011). How Children Get to School: School Travel Patterns from 1968 to 2009. Online at: http://www.saferoutesinfo.org/program-tools/NHTS-school-travel-1969-2009.

Reprise

- End goal of teaching with data
- Learning progression with several difficult transitions
- Focus on transition II: from small-student collected datasets to large-professionally-collected data sets
- Students' lack of experience with big data
- Components of transition II
- Two strategies to support transition II
  - Hypothesis array
  - Hybrid activities

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Questions?

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