What do Geoscience Novices & Experts Look at and What do They See when Viewing and Interpreting Data Visualizations?

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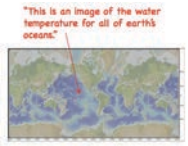
Context

What we know:

- Interpreting data visualizations is central to the professional practice of most kinds of geoscientists
- Geoscientists can make inferences about structures, processes and history from data representations--even when they didn't see the causal event, and even when they have not personally experienced the place depicted
- Many students cannot do this—even when the data visualization is highly iconic, resembling the referent

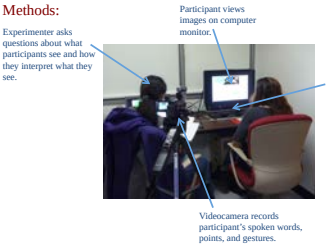


From prior study:
Swenson, S., & Kastens, K. A. (2011). Student Interpretation of a Global Elevation Map: What it is, How it was Made, and What it is Useful for. In A. Feig & A. Stokes (Eds.), *Qualitative Inquiry in Geoscience Education Research (pp. 189-211): Geological Society of America Special Paper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

What we wish to find out:

- How do experts do this?
- How can we help students move towards this ability?
- How do students approach the task of interpreting a data visualization?

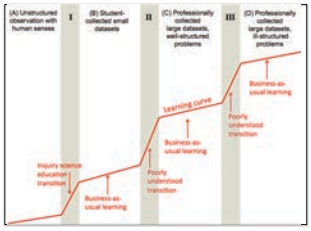
Methods:



Full Research Plan, this project:

- Study #1: Expert/novice comparison of what individuals attend to and what they report seeing in bathymetric/topographic data
- Study #2: Intervention study: Does providing a "hypothesis template" improve students' ability to visualize and interpret a 3-D data volume, and if so, how?

Towards a Ten-year Research Agenda:



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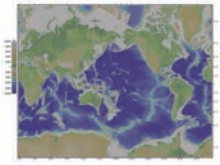
FIRE: Fostering Interdisciplinary Research in Education

Protocol

Novices:
- Temple University undergrads in psychology participant pool, mostly female
- We ask if they have taken any earth science in college; most have not
- 45 useable participants, after omitting some incomplete data files

Experts:
- Professional geoscientists on staff of Lamont-Doherty Earth Observatory
- at least 10 years of geoscience research experience
- 12 useable experts

Everyone saw global map first:



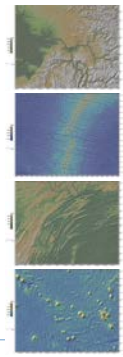
(2.1) What do you think this is? [follow up questions, until they commit to an interpretation]

(2.2) OK, good, so you have told me that you think this is a [*map/image/picture*] of [*interpretation*]. What clues in the image led you to think that it shows [*interpretation*]?

(2.3) Was there anything else in the image that led you to that interpretation?

(2.4) Could you please point to an example of where you think the image is showing [*interpretation*]?

Then they saw four high resolution images, in random order:



(3.1) What do you think this image is showing? [follow-up questions]

(3.2) What processes do you think might have shaped this part of the Earth's surface? [follow-up]

(3.3) Can you give me any more detail about what you think is going on in this image?

(3.4) What do you think you would see if you could see a larger area of the Earth than we are seeing here, if you could see outside the frame of this image? [follow-up]

On each hi-res image, specific areas were highlighted for further questioning:

(3.5) Please describe to me what you see in and around the area that was just marked. While you are answering this question, please pretend that I'm in another room and can't see the image; just use words to describe the marked part of the image as best you can.

Wrap Up Questions (novices only):

(4.1) How do you think these images that we've been looking at were made?

(4.2) What do you think these images are useful for?

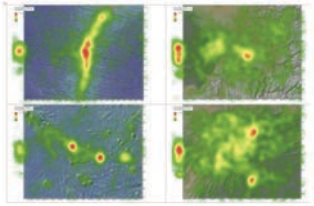
(4.3) Think back over all the images. As you were trying to come up with the answers to my questions, what sources of knowledge did you draw on?

(4.4) Now I'm going to read you a list of sources of knowledge that some people use as they try to interpret these types of images. For each choice, tell me whether that was one of the sources of knowledge you used….

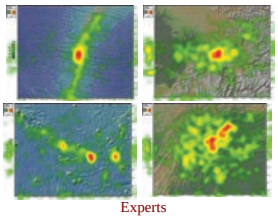
Findings

Ocean versus Continent:

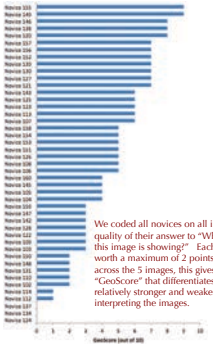
- Eye-tracking data presented in this poster are from 20s unguided exploration of image before questioning began.
- Note the strong pull towards the center of the image, also seen in previous eye-tracking studies
- Continental images differ from continental images. Eye-tracking on continental images is diffuse; on oceanic images it is more focused. Does this reflect the shorter, simpler geologic history of oceanic crust?
- At this overview and aggregated level, novices and experts are similar.



Novices



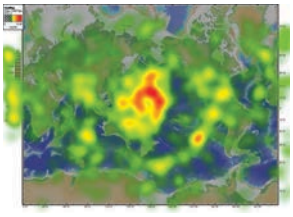
Experts



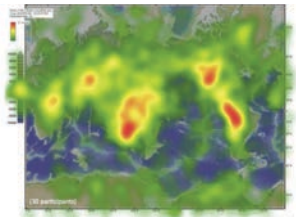
We coded all novices on all images on the quality of their answer to "What do you think this image is showing?" Each image was worth a maximum of 2 points. Summing across the 5 images, this gives us a ten point "GeoScore" that differentiates novices with relatively stronger and weaker proficiency at interpreting the images.

The lure of the familiar:

- On the global image, experts and novice differ. Novices tend to spend a disproportionate amount of attention on the continents (48% of the image) relative to the oceans.
- Relative to its size, North America (7.3% of image) gets extra attention from the novices.
- Experts allocate their attention more evenly between ocean and continents.

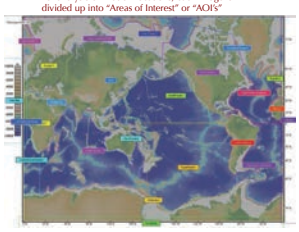


Experts



Novices

For analysis of fixation locations, each image is divided up into "Areas of Interest" or "AOI's"

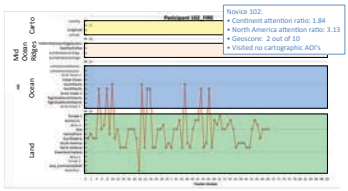


Allocation of attention to all continents and to North America

% of time spent in AOI / % of image that is in AOI	Experts Mean(SD)	Novices Mean(SD)
All continent AOI's	0.94 (.30)	1.47(.28)
North America	1.00(.89)	1.83(.89)

In their initial 20s of unguided exploration, experts allocate attention (time) to continents and to North America approximately in proportion to their area on the image.

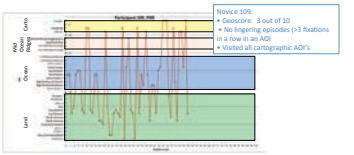
Novices, on the other hand, spend more time on continents (especially North America) than expected from the percentage of image area alone.

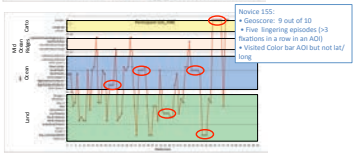


High GeoScore novices are more expert-like in their allocation of attention between North America and the rest of the image.

Flitterers versus lingerers:

- Some participants jump around, seldom alighting in one AOI for more than one fixation. Others linger, investing multiple fixations in a row in the same AOI.
- We had an initial impression that lingering was more characteristic of experts and high-GeoScore novices, while flittering was concentrated among low-GeoScore novices--but that impression did not hold up to scrutiny. Perhaps lingering versus flittering is best thought of as an individual difference?





A missed opportunity in the cartographic information:

- Many novices ignore the available cartographic information during their initial 20s unguided exploration of the image.