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Diagrams, Images, and Novices. Oh My!

Experts have developed many more mental connections than novices, and they've taken considerable time to do it. We seldom consider how our ability to read diagrams and graphs or interpret images differs from the novices we teach. Dr. Julie Libarkin recently visited EOAS with some suggestions on how to reduce cognitive load and make visuals easier on novices (i.e. our students). In her talk, Dr. Libarkin described three experiments from her research group, and made recommendations for best practices when using images.

Experiment 1 – Inexact models persist throughout the development of expertise. Misconceptions gradually reduce as expertise is developed

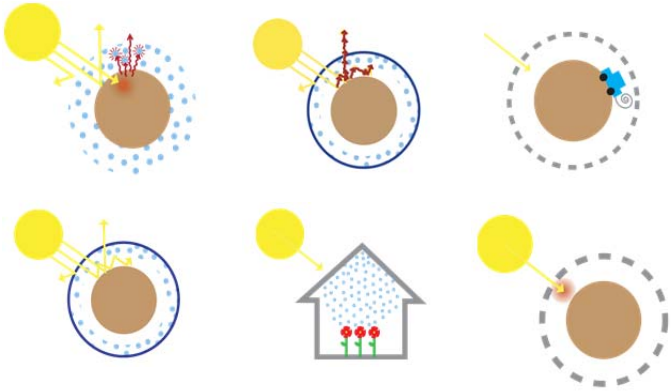


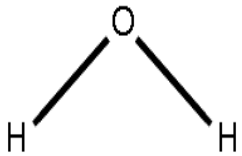
Figure 1 - Graphical representations of mental models of the Greenhouse Effect

In one experiment Dr. Libarkin's group investigated mental models of the greenhouse effect held by a variety of groups, from students to experts. These models can be categorized based on their attributes and the misconceptions they display. All student models contain misconceptions, however, even models that experts profess contain some misconceptions. The important conclusion to draw from this work is that even experts have misconceptions about what they study. However, because experts can reason effectively from inexact models, and because it is possible to be successful with incomplete models, we do not have to worry (too much) about perfect scientific accuracy in teaching. To students, for example, the Bohr model of the atom can still be quite useful in many contexts. We can use incomplete expert models as clues to "necessary" parts of our instructional images

Take home message: Experts can reason effectively from inexact models

Experiment 2 – Even simple representations can be difficult

Consider the three representations of water to the below. Most experts would consider these are largely identical, however when students are asked to describe them, they assign different words and meaning to each of the diagrams.



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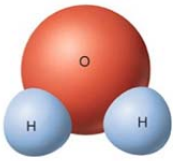
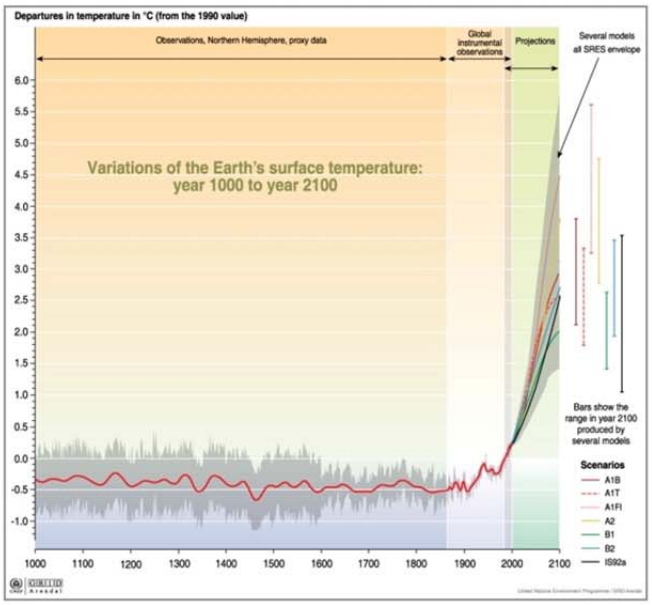


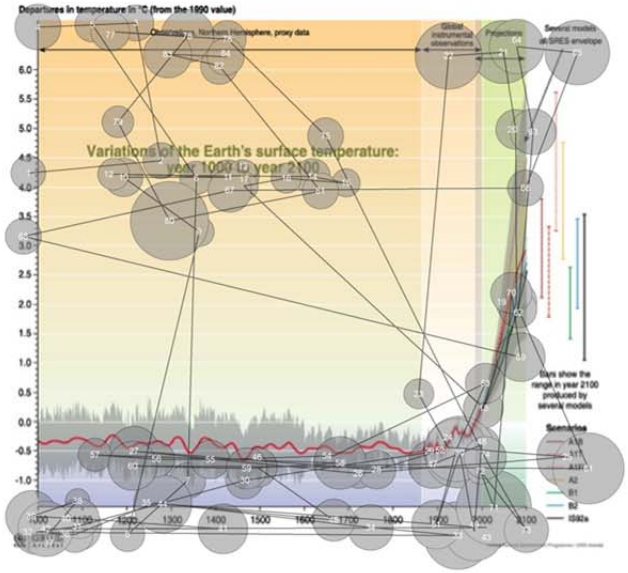
The same holds true for the more complicated diagrams we use in our teaching. For example in traditional textbook images showing Subduction most experts, and many students, would summarize such diagrams as: Geological Subduction or a Convergent boundary. Some students see obliquely related topics; such as Tectonic plates, Volcano, Mountains, Earthquake, Earth's layers, Geology/Earth Science, Continents Shift, or Topography . But some students relate it to Rain, Rising Sea Level, or Runoff.

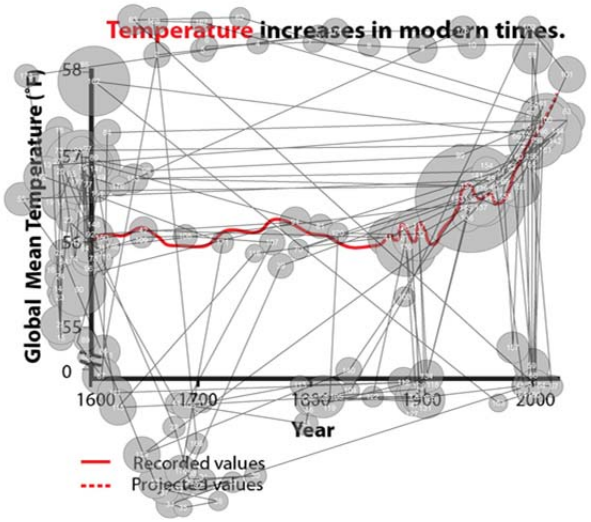
Take home message: Students don't always "see" what we expect them to see, even for our simplest representations. We should be very explicit in our descriptions.

Experiment 3 – Novices don't interact with figures in the same way that experts do.

In academia we have been trained to put as much information as possible in our images and diagrams. While this is useful when we are communicating with other experts, it inhibits our ability to speak with novices. The image below is from the Intergovernmental Panel on Climate Change. It contains much information, but can be overwhelming for novices. On the right, image tracking software was used to determine where novices looked when observing the image. The path they followed is indicated by the lines, and the amount of time they spend looking at each point is indicated by the size of the circle (and the number). You will notice that the novice only rarely looks directly from a point on the line to an axis.







In contrast a simplified image (left) allows the novice to use the image much more like an expert would. This novice directly compares points on the line to both of the axes.

Take home message: Visual message can be easily lost when we display the "complete correct" message. Simpler design produces better physical and cognitive interactions

Recommendations:

- **Evaluate how MUCH of the model needs to be taught through expert research**
- **Do not assume people understand even simple visuals**
- **Choose ONE message per visual**

[1] CWSEI: http://www.cwsei.ubc.ca/resources/index.html EOS-SEI: http://www.eos.ubc.ca/research/cwsei/

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