Global Climate Models for the Classroom: A Review of Active Learning in Inquiry Climate Change Teaching and Its Implications for New Educational Technologies

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The challenge of teaching Earth Science and AGCC

- Requires the integration of observational data, laboratory results, and computer modeling (McCright et. al., 2012).

- Often includes post-dictive or retrodictive reasoning with high levels of background knowledge (Oh, 2011).

- Necessitates reasoning that can't always be compared versus local experience (Akerloff et. al., 2013; Myers et. al., 2013).

What types of active learning?

"Being engaged by scientifically oriented questions, using evidence to evaluate these questions, formulating answers to the questions, evaluating alternative explanations, and communicating explanations" (National Research Council, 2000).

This includes experiential, problem-based, active, collaborative, open and guided forms of learning.

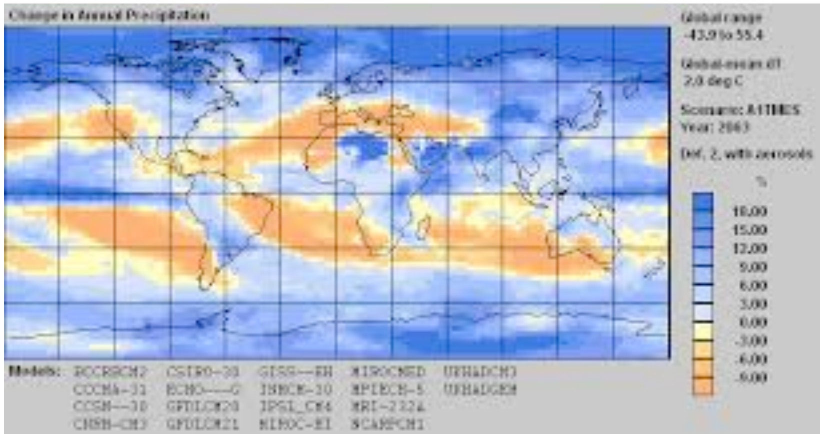
The debate

Without guidance students do not learn well and have trouble following the scientific paradigm due to the cognitive nature of the brain (Kirschner et. al., 2006).

VS.

As students focus on both of these areas they also gain comprehension of scientific content rather than the rote memorization of facts and ideas (Keys & Bryan, 2001)

Until recently, a very large gap…



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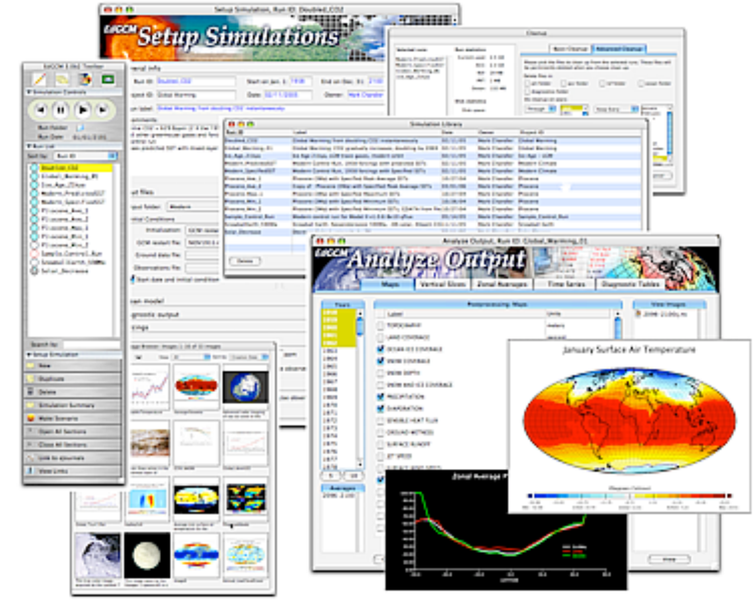

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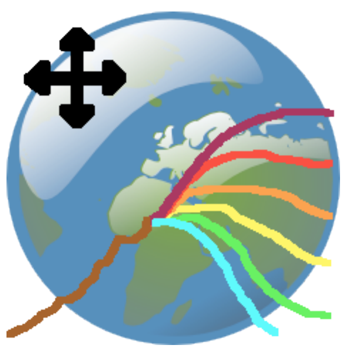

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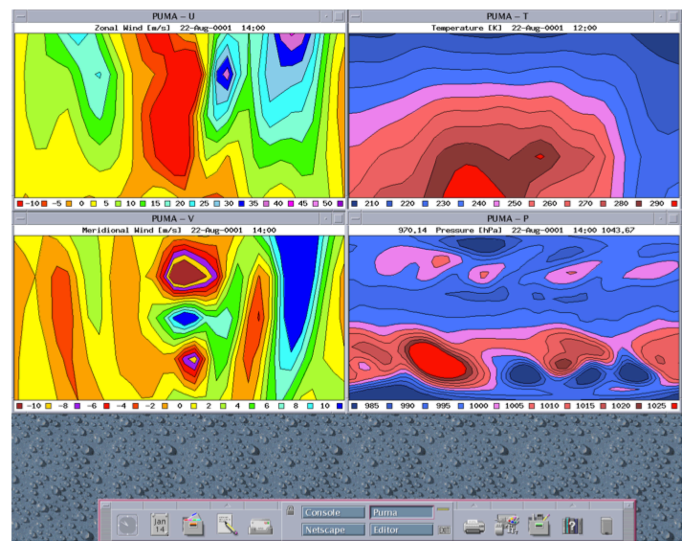


Image courtesy of Meteorologisches Institut Universität Hamburg

Guiding principles from educational research

The Good News:

- 553 Midwest United States 7th & 8th grade students report higher interest in activities that were hands-on in nature, particularly "those that involved the use of scientific instruments or technology" (Swarat, Ortony, & Revelle, 2012).

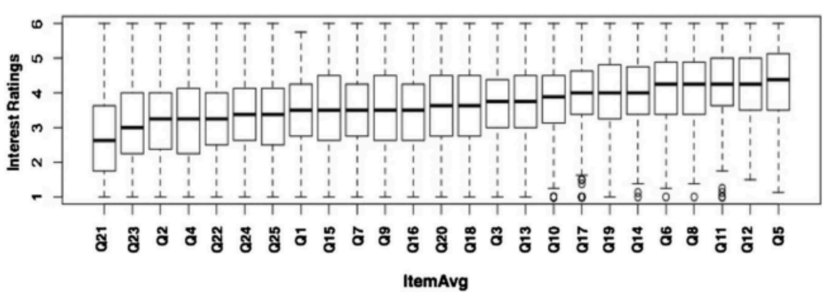


Figure 2. Box plots of ItemAvg (box showing median, 25th and 75th percentile). *ItemAvg refers to the average rating of the same item across topics. For example, ItemAvg of Q3 refers to the average rating of item 3 across all topics. **The specific items can be found in Supporting Information Appendix 1.

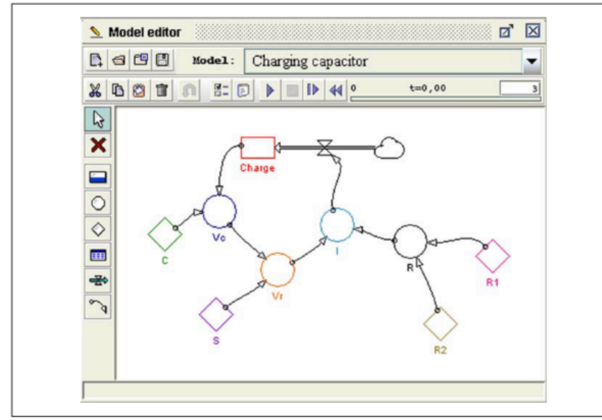


Figure 1. Screen capture of the model editor tool displaying the reference model students had to build from their prior knowledge and/or insights gained through experimenting with the simulation. Students could add, delete, and change elements and relations to their models with the buttons on the left. The buttons in the top center of the screen enabled students to perform runs on their models.

The Caveat:

- 203 Dutch students lacking background knowledge (in comparison to older more knowledgeable peers) construct and modify models poorly without seeking to adequately understand the program or the scientific concepts.
- Strong support and guidance required.

(Mulder, Lazonder, & de Jong, 2015)

Practical considerations (1)

- Ensure adequate time
- Actively demonstrate usage
- Technology with design flaws can be an impediment
- Carefully plan implementation

(Edelson & Gordon, 1998; Edelson, Gordon & Pea, 1999; Edelson & Reiser, 2006; Edelson et al., 2006)

Image courtesy of esri.com

Daniel Edelson and many others: Decades of research using various visualizers (i.e. "Greenhouse Effect Visualizer"), Planetary Forecaster and GIS technologies.

Collaboration improves learning (2)

- The Globe Network involves scientists in designing protocols for data collection and mentoring students on climate science investigations (Charlevoix, Tessendorf, & Mackaro, 2011; Tessendorf et. al., 2012; Butler & Macgregor, 2003).

Place-based strategies work (3)

- Using GoNorth! Arctic National Wildlife Refuge and ArcGIS, 65 middle school students in the Midwest and Northwest United States study differences in environment (GoNorth!, 2006; Doering & Veletsianos, 2008).

- Over six months, 64 middle and high school students in Colorado make videos on "locally relevant climate change topics" (Gold et. al., 2015).

Visualization is powerful (4)

- The WISE computer program allows students to explore albedo, carbon dioxide emissions, population, and pollution as factors leading to AGCC (Svihla and Linn, 2012).

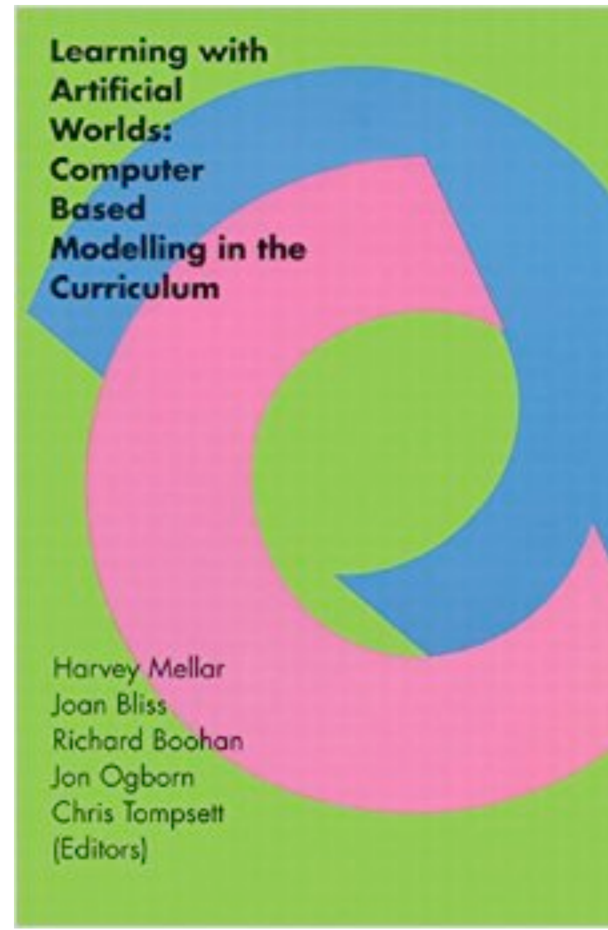
- Carleton College's EarthLabs involves students in six to nine rigorous sequenced laboratory activities examining satellite imagery, numerical data, and computer visualizations (Ledley et al., 2012; Ellins et. al., 2014).

What level of modeling? (5)

Many studies fall into two categories defined by Joan Bliss in 1994.

1. **Explorative** modeling involves using a model representing someone else's ideas by trying it out and perhaps modifying it slightly.

2. **Expressive** modeling involves learners in constructing their own computer model.



Summary

- Build processes, ideas and course themes with appropriate level of technology incorporated as needed.
- Provide strong guidance and demonstration of working with any program or technology.
- Use collaboration and place-centered strategies to positively impact student learning.
- Ensure adequate time for the technology and the background knowledge needed to support it.

Thank you!

Please feel free to contact me with any questions, for a list of the literature cited, or other requests at

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