Matthew John Brewer
iMovie Script Changing Schools Fall 2005

Outline of Scenes:

1. Introduction
    a. Question: How do you visualize something that is too large to see? What is the most effective to visualize the structure of the earth at a fifth and sixth grade level?
    b. Quote from Gobert (2005) abstract, "geology is a semantically rich domain…"
    c. What types of models — conceptual/physical — are best?

2. Alternative Conceptions
    a. Alternative conceptions in Earth Science
    b. Libarkin et al (2005), tectonic model(s)
    c. Preliminary results

3. Models
    a. Two types — conceptual/physical (cf. IES)
    b. Developmental
    c. Conceptual Change Model (Gobert 2005, Steer et.al 2005)
    d. How best describe the earth structure (egg — earth)

4. Approaches/Curriculum
    a. Tangible evidence
        1. IslandWood

5. Conclusion
    a. Summary of
        1. Alternative conceptions
        2. Models
        3. Results
    b. Revisit question

Script

Begin 00:00:00

*Title*
Effective Modeling in Geosciences

Models permeate throughout education, especially geosciences. Often students develop naïve theories that perpetuate their alternative conceptions into adulthood. This video is an examination of modeling efficacy in the geosciences, especially the structure of the earth with as much tangible evidence as possible.

Created by Matthew John Brewer
November 2005

*Matt:*
How do you visualize something that is too large to see?
[*Image — inner structure of the earth, 90.jpg, Ambrose Video 2005*]
How do you visualize something that moves imperceptivity slow yet has catastrophic human potential?
What is the most effective way to visualize the structure of the earth at a fifth and sixth grade level?
[*Movie — lg01PacN.mov,* Atwater 2002a].

"Geology is a complex, semantically rich domain involving the interpretation of geological maps as external visualizations. Geological maps are complex in particular because 3-dimensional features must be inferred from 2-dimensional representations depicted by differing line types and weights. (Gobert 2005:444).
[*Movie — 02Pac-NoAm.mov*, Atwater 2002b].

Modeling building, as an internal mental activity, is also required in order to achieve deep understanding of textual materials in geology, of geological maps, as well as in understanding complex casual processes, e.g. convection, underlying geological phenomena." (Gobert 2005:444).

What is the best type of model to explain this complexity?
Let us first examine some common alternative conceptions in Earth Science.
[*Image — core,* Lahr 1999,
*image — washington2,* and *fig1s,* Rhea 2005
*Movie — 10conejoVolcanics.mov,* Atwater 2002c
*Image — FigS1-1,* USGS 1999]

*Matt*:
An alternative conception is a misunderstanding based on our own naïve theory or theories that we use construct meaning of a given concept.
Recognizing alternative conceptions in Earth Science are especially important because the scale is beyond human understanding in three ways: it is larger than our spatial sense, includes an unimaginable amount of time, and requires cognition of concepts that are unobservable.
[*Image — FigS1-1,* USGS 1999,
*Image — satellite image of the earth,* Ali-Dinar 2005
*Image — tower of time,* Chronos System Portal 2005
*Image — earth-surface,* KMR 2003].

Take, for example, the this diagram
[*Image — tectonic model(s),* Libarkin et al 2005]
Which one of these models is correct? How do you know? Why is one more accurate than others?

I have given this figure to fourth and fifth graders who predominantly think that the answer is "B". Why is that? What would happen during mountain building, volcanic eruptions, and earthquakes if the plates are not on the immediate surface? Examinations of effective modeling must be completed before we can revisit this complex problem.

*Matt*:
In science there are many kinds of models or ways of modeling but they generally fall into four categories: Physical, Conceptual, Mathematical, and Numerical.
[*Title — "Types of Modeling in Science, Four Categories: Physical, Conceptual, Numerical, Mathematical*
*Image — solar system structure,* Hathaway 1998
*Image — atom with orbitals,* How Stuff Works in Science 2005
*Image — meteorology work station,* Fandrick 2005]

Another effective modeling technique is a schema that includes and incorporates means to conceptually change the model throughout.
In the Preconception phase, a) students face and discuss their preconceptions. Students create novice models, are presented with conflicting data and made revisions in b) the Model Development Phase. At c) students evaluate their models and begin to develop mental models that emphasize processes. Mental models are validated at d) as students apply their mental models in new situations or to more advanced topics.

[*Image* — Steer et.al. 2005:416[.

What then is the best way to describe the earth structure? Let us consider some examples.
[*Image — satellite image of the earth,* Ali-Dinar 2005
*Image — earth-surface,* KMR 2003].

*Matt:*
"The size of the Earth -- about 12,750 kilometers (km) in diameter-was known by the ancient Greeks, but it was not until the turn of the 20th century that scientists determined that our planet is made up of three main layers:
[*Image — satellite image of the earth,* Ali-Dinar 2005]

Crust, mantle, and core.
[*Image — inner structure of the earth, 90.jpg,* Ambrose Video 2005]

This layered structure can be compared to that of a boiled egg. The crust, the outermost layer, is rigid and very thin compared with the other two.
[*Image — boiled egg, cut in half, with chip in middle; footage taken by author*]

Beneath the oceans, the crust varies little in thickness, generally extending only to about 5 km. The thickness of the crust beneath continents is much more variable but averages about 30 km; under large mountain ranges, such as the Alps or the Sierra Nevada, however, the base of the crust can be as deep as 100 km" (USGS 1999)
[*Image — change from egg to core, done by author*
*Image — core,* Lahr 1999
*Image — FigS1-1,* USGS 1999]

| *Earth layer name* | *Thickness (km)* | *Percentage of Thickness* |
|---|---|---|
| *Lithosphere* | *100* | *1.5* |
| *Mantle* | *2900* | *44* |
| *Outer Core (liquid)* | *2300* | *34.5* |
| *Inner Core (solid)* | *1200* | *20* |
| | *6500 (radius)* | *100* |

The distance from the surface to the center of Earth is 6378 kilometers.
[*Image — core,* Lahr 1999]

The Lithosphere — including the crust and upper most solid mantle — with a thickness of 100 km represents 1.5% of the radius. The Mantle with a thickness of 2900 kilometers represents 44% of the radius. The Outer Core with a thickness of 2300 kilometers represents 34.5% of the radius. And the Inner Core with a thickness of 1200 kilometers represents 20% of the radius."
[*Image — display table above*].

[*Example that follows from* Ford 2001, *footage taken by author*].
In my hand I have a hard-boiled egg. What will happen if I tapped the egg on a hard surface? Like the lithosphere the shell of the egg is brittle and can break. Now I am going to tap the egg on this hard surface and outline some of the cracks so that there are eight large "plates" and about eight small ones.
[*Perform the action described, transition into close up*]

Now I am going to cut the egg in half. One half of this egg will model the Earth's cross-section.
The dot that I am making will represent the Earth's inner core. The shell represents Earth's lithosphere—the crust and the rigid part of the upper mantle that together form Earth's plates. The yolk represents the outer core and the colored dot in the yolk's center represents the inner core. The egg white represents the lower portion of the mantle.

How does this model effectively mirror the structure of the earth, given the information about each layer that we recently saw? (Ford 2001)
[*Image — change from egg to core, done by author*
*Image — core,* Lahr 1999
*Title — "Follow Me Into an Active Earthquake Fault*].

[Begin 6:19:00 — Montage
Images (in order of appearance by citation: Ali-Dinar 2005; NASA 2005; Google Map images centered on IslandWood; IslandWood Aerial Photo (courtesy of IslandWood); PSLC 2003; Sherrod 2003b.
End 6:51:16].

[Begin 6:52:15 — *fade into movie of instruction taken by author May 23, 2005, followed by photos taken by author at the end*
*:*
*At the IslandWood fault. Matt is standing next to the trench wall in blue; Brian Sherrod is to Matt's right (left on the screen) wearing an orange vest. Seven*

*students are seated on the ground looking at the trench wall. Each student has a journal and a pencil; they have just completed their drawing of the trench wall.*]

*Matt:* So, now that we know that this is the bedrock [*places hand on the wall on the bedrock*] and this is brought by glaciers [*places hand on the wall on the glacial till*], if it were perfect and we had our law of superposition where would the rocks be?

Let me rephrase that. What is superposition, again?

*Student:* Older rock on the bottom, younger rock on the top

*Matt:* No, you started the younger rock on the top and the older rock on the bottom. Good. Unless what happens?

*Student: [inaudible]...*

Matt: Okay, so, the bedrock is older or younger?

*Student:* older.

*Matt:* older.

And the glacier is?

*Student:* younger.

*Matt:* So, how come it's on top? How come the bedrock is on top?

*Student:* there was an earthquake.

*Matt:* Where is the earthquake? Where's the, where does it divide between the two?

*Student:* there's a fault right there.

*Brian:* So, you say there's a fault right there, eh?

*Matt:* Where's the fault? Get up and point at it. Get up and point at it.

[*Student goes up to the wall and traces his hand along the fault*].

Excellent.

*Brian:* Very good. But what's the thing that jumps put in your mind when you first look at that? You guys probably saw that as soon as you walked in here. What's the first thing that you recognize there? Just real quick what's the first thing that you see where that fault is?

*Student:* a different color.

*Brian:* A different color. It can be, it can be as quick as that. Look! Those things are different colors. You automatically saw that something was different there and that probably drew you mind, drew your eye that.

End 8:27:15, total time 1:35:00].

*Title* [effect Gravity]:
"Are you Ready… …For a Test?"

*Matt:*
"Which is the best analogy? The thickness of an egg shell is approximately 1-2% of the radius of an egg. This is analogous to the thickness of the __________ relative to the radius of the Earth.

a. oceanic crust		b. continental crust
c. Lithosphere		d. mantle" (Steer et. al. 2005:419):
[*Image — text of the question above*].

If you said "C" you are correct. 100 kilometers represents that thickness of the Lithosphere, which is approximately 1-2% of the radius of the Earth.
Remember that the lithosphere contains oceanic and continental crust as well as the upper most solid mantle.
[*Image — egg cross section, taken by author*
*Image — core,* Lahr 1999]

*Matt:*
Many times things are complex because we make them complex or we forget there are alternatives that integrate multiple ways of knowing.
We must use tangible evidence in the geosciences.
[*Image — IW_trench_photo,* Sherrod 2003b]

[*Title — Bibliography (see text below); Music by DJ Shadow, Mongrel; Created, Filmed, and Edited by Matthew John Brewer*]

End 10:10:07]

Bibliography

Ali-Dinar, Ali B.

(2005). *African Studies Center: Maps & Satellite Images*. http://www.sas.upenn.edu/African_Studies/Map_Satellite/eg860921_Globe_13348.gif. Visited October 5, 2005.

Ambrose Video Publishing

(2005). *90.jpg 720x486 pixels*. http://www.ambrosevideo.com/resources/-docs/90.JPG. Visited October 5, 2005.

Atwater, Tanya

(2002a). *Pacific Hemisphere Plate, 80 Ma to Present*. URL: http://animations.geol.ucsb.edu/animations/quicktime/lg01PacN.mov. Visited May 9, 2004.

(2002b). *N.E. Pacific and W. North America Plate History, 38 Ma to Present*. URL: http://animations.geol.ucsb.edu/animations/quicktime/sm02Pac-NoAmflat.mov. Visited May 9, 2004.

(2002c). *Miocene: Rifting and rotation, volcanism, crustal upwelling and deposition in marine basins*. URL: http://animations.geol.ucsb.edu/animations/quicktime/sm10conejovolcanics.mov. Visited May 9, 2004.

Chronos System Portal

(2005). *Tower of Time*. http://www.chronos.org/downloads/-toweroftime.pdf. Visited October 9, 2005.

Fandrick, Ron

(2005). *Album #1 — Hurricane Frances (2004)*. Updated June 1, 2005. http://www.rwf2000.com/FGifs/Meteorologist.jpg. Visited October 5, 2005.

Ford, Brent A.

(2001). *Project Earth Science: Geology*. For Grades 6-8. Supported by the National Science Teachers Association. Arlington, VA: NSTA Press.

Gobert, Janice D.

(2005). "The Effects of Different learning Tasks on Model-building in Plate Tectonics: Diagramming Versus Explaining." *Journal of Geoscience Education*, v.53, n.4, September 2005. Pp.444-455.

Hathaway, David H.

(1998). *A Scale Model of the Solar System.* http://science.nasa.gov/ssl/pad/solar/tutorials/images/solar_system_model.jpg. Visited October 9, 2005.

How Stuff Works in Science

(2005). *The Atom and orbitals.* http://science.howstuffworks.com/atom8.htm. Visited October 7, 2005.

Knowledge Management Research Group (KMR)

(2003). *Earth-Surface.jpg.* Updated October 27, 2003. http://kmr.nada.kth.se/math/pointfocus/Earth/Earth-surface.jpg. Visited October 9, 2005.

Lahr, John C.

(1999). *How to Build a Model Illustrating Sea-Floor Spreading and Subduction.* USGS Open-File Report 99-132, On-Line Edition. Updated July 8, 1999. http://pubs.usgs.gov/of/1999/ofr-99-0132/. Visited October 5, 2005.

Libarkin, Julie C., Anderson, Steven W., Dahl, Julie, Beilfuss, Meredith, Boone, William

(2005). "Qualitative Analysis of College Students' Ideas about the Earth: Interviews and Open-Ended Questionnaires." *Journal of Geoscience Education*, v.53, n.1, January 2005. Pp. 17-26.

Puget Sound LIDAR Consortium (PSLC)

(2002). Updated March 3, 2002. http://duff.geology.washington.edu/data/raster/lidar/About_LIDAR.htm. Visited November 23, 2003. Image created by Matthew John Brewer, adapted from t24nr023_ne.jpg and t25nr02e_se.jpg available on the web. Visited May 23, 2004.

NASA

(2005). *SVS Animation 2248 — Great Zoom out of Seattle, WA: The Space Needle.* "Image Western Washington — http://svs.gsfc.nasa.gov/vis/a000000/a002200/a002248/zoomSeattlestill.0350.tif; and Puget Sound — http://svs.gsfc.nasa.gov/vis/a000000/a002200/a002248/zoomSeattlestill.0575.tif. Visited October 10, 2005.

Rhea, Susan

(2005). *SHIPS – Overview*. Updated October 14, 2005. http://earthquake.usgs.gov/regional/pacnw/ships/brocher01/. Visited October 19, 2005.

Smith, Michael J., Southard, John B., Mably, Colin

(2002). *Investigating Our Dynamic Planet (Teacher's Edition)*. For Grades 5-8. Investigating Earth Systems: an Inquiry Earth Science Program, supported by the American Geological Institute Foundation and the National Science Foundation. Armonk, NY: It's About Time, Inc.

Sherrod, Brian

(2003a). USGS Paleosiesmolgist, excavator of the IslandWood trench August 12, 2003 to September 7, 2003. Personal Communication with author August 22, 2003.

(2003b). Paleoseismology, Presentation at GSA Conference 2003, Seattle WA on Nov. 7, 2003. Available on power point, slides 22.

(2005). USGS Paleosiesmolgist, excavator of the IslandWood trench August 12, 2003 to September 7, 2003. Personal Communication and Video Footage with author May 25, 2005.

Steer, David N., Knight, Catherine C., Owens, Katherine D., McConnell, David A., (2005). "Challenging Students ideas About Earth's Interior Structure Using a Model-based, Conceptual Change Approach in a Large Class Setting." *Journal of Geoscience Education*, v.53, n.4, September 2005. Pp.415-421.

United Sates Geological Survey

(1999). *Inside the Earth (This Dynamic Planet, USGS)*. Updated May 5, 1999. http://pubs.usgs.gov/publications/graphics/FigS1-1.gif. Visited October 5, 2005.