Storytelling with Uniview #03:
The Shape of the Earth

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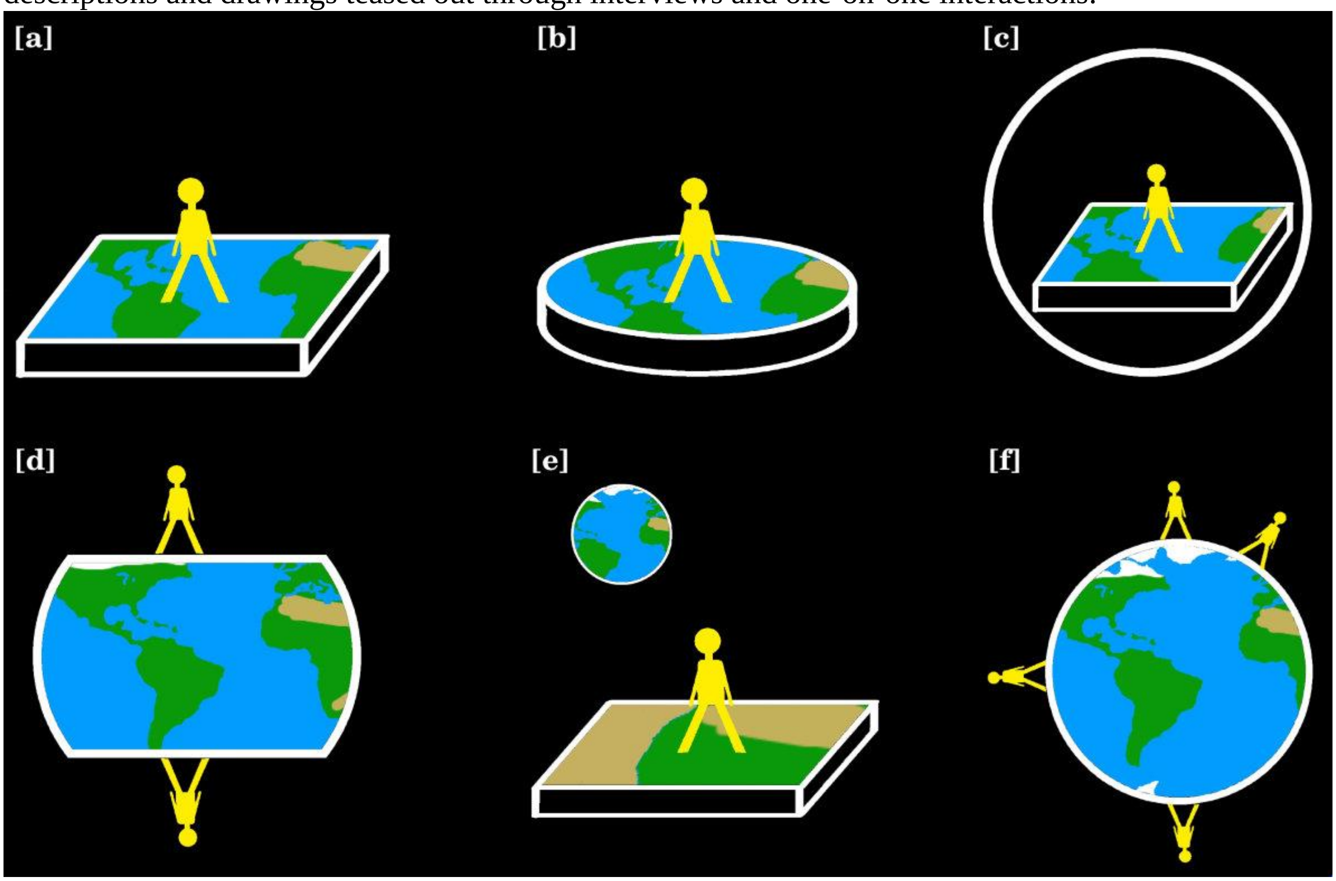
Should we care about teaching the shape of the Earth? Doesn't everyone know that the Earth is round? Isn't it obvious from the proliferation of globes, posters, TV documentaries, and science fiction movies to any child or adult that the Earth is shaped like a ball? Didn't students learn that Columbus discovered the New World and confirmed that it was round?[1]

Well it turns out that at least for very young children, the shape of the Earth is not obvious. Substantial amounts of research has been done over the last several decades to probe the alternate—i.e., non-scientific—conceptions that people have. These studies have been done for many different age groups and most topics in science, but the ones for astronomy are particularly eye opening.

Take this set of diagrams summarizing the mental models uncovered in young children, based on verbal descriptions and drawings teased out through interviews and one-on-one interactions:



Similar results have been found by different researchers in many different populations of students, in a variety of different cultures. If you look carefully at this, the progression of models makes some sense.

[1] Actually this last statement is hooey—Columbus did no such thing since most learned people even in his time knew the Earth was spherical.

The youngest children have only their direct experience to help them understand the world. So when asked what the world is shaped like, their mental models will be based on two "obvious" facts: that their world looks, for all intents and purposes, to be flat; and gravity pulls in the downward direction to keep people and things anchored to the Earth. Thus the most primitive models show a flat tabletop-like Earth, with either square corners or a rounded outer edge.

But presumably even young children are exposed to descriptions of a round Earth, are shown globes and images of Earth from space. Why don't children progress to the familiar globe model instead of the bizarre intermediates?

This can be explained in part by an educational theory known as constructivism. The basic idea behind this is that we learn not just in school or from teachers, but from our everyday experience with the environment around us. This can include not only our observations of the natural world, but what we read or see on the Internet, what we view on television, and what we hear or overhear from family, friends, and instructors.

But people do not learn by having new information entering their heads and pushing out the old mental model. Our ideas can be deeply held, and very resistant to change. Often the best that new information can do is to make a slight modification to the older mental model. Thus instead of a wholesale change from a flat tabletop Earth (a) to the shining Blue Marble, when a young child hears that the "Earth is round," his mental model might only go from a flat Earth with square corners, to one with a round border (b). As more contradictory information about the Earth piles up, the mental model changes. Maybe a spherical Earth starts to sound convincing after the learner hears about it from multiple sources. But the everyday experience of a flat Earth is hard to discount, so that is why you see Earth globes with a flat interior (c), or a spherical Earth with flat sections (d).

But what to make of the strange dual Earth model in (e)? Interviews reveal that this model originates from seeing pictures of Earth taken by astronauts far in space. These images imply that there is an Earth that floats in the sky or in space, which is physically distinct from the flat Earth where the child and everyone she knows lives.

Given enough time, the child's mental model of the Earth will evolve. This does not happen necessarily smoothly, nor do the mental models have to go through the progression that we see in the above diagram. Different children will arrive at the correct scientific model at different times, with some children having problems up into middle school. But with enough instruction, eventually resistance to the notion that gravity only pulls in a downward direction will fade, and the correct idea that gravity pulls towards the center of the Earth will take hold. The spherical Earth in (f) doesn't seem so far-fetch anymore, and the learner can finally accept the idea of a round Earth without nagging doubts about falling off its surface.

Unfortunately on the Orbits Table, it is not possible to land on and see a high resolution view of the Earth's surface[2]. But when I am at that station and a young child comes to visit, I never take it for granted that he or she knows about the Earth's true shape. (It's unlikely the parent or guardian understands their child's misconception either.) Thus in this situation, if I am over the Earth, I will tend to zoom in towards the surface, or lock the camera to the ISS. I can then point out that when we are close to the Earth, it appears flat. (This usually requires panning the camera until the horizon is visible

[2] Those of you who fly Uniview in the dome do have that capability, and with the high resolution NAIP layer, you can even bring audiences close enough to the surface to see familiar buildings in Denver.

with Ctrl+Left Mouse Button.) Because it is so big, Earth's roundness is not apparent until we zoom out. Pointing out where Denver or Colorado is (if you can find them) is another way to reinforce the point that we and everyone in that room live on a round planet.

Of course the Orbits Table is not the only device in Space Odyssey that can be used to show the Earth. Pointing out that we live on a globe so big that it appears flat to us can be part of facilitation with the Science On a Sphere when small children are involved. But perhaps the most appropriate Earth display in the *Space Odyssey* exhibit to use is the Onomy Tilt Table, running the Google Earth-esque World Wind software from NASA JPL. It is rarely facilitated, but because it can literally show someone's house or school, it is ideal for emphasizing to younger visitors that we live on a ball which is so big that it looks flat from our ground-based perspective; that gravity pulls towards the center to keep everything on its surface from falling off; and that we can locate ourselves (or at least our proxy domiciles and schools) within this simulation and make visible our connection to a round world.

References

Agan, L., & Sneider, C., 2004, "Learning About the Earth's Shape and Gravity: A Guide for Teachers and Curriculum Developers," *Astronomy Education Review*, 2(2), pp. 90-117.