## ArcGIS and Google Earth: Rules of Engagement

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***Abstract:*** *Google Earth and ArcExplorer give casual users a richly visual, instantly engaging, easily navigated view of the world. Point-and-click simplicity means instructors can casually add geographical experiences to their courses. The naturalistic metaphor of Google Earth complements the data-driven power of ArcMap; ArcMap accepts a wider variety of data, performs more sophisticated analyses, and provides more abundant options for displaying the results. The presenters will describe their experiences using free earth viewing software in the classroom and the high levels of student engagement they have observed. They will describe classroom applications that use Google Earth and ArcExplorer as a delivery vehicle for ArcView maps. They will survey classroom applications from other campuses, and summarize the strengths of the different tools, including ArcExplorer.*

The two authors chose to write about this topic after independently observing the instant enthusiasm that virtual earth software generated in classrooms at their respective colleges.  This year the Williams College Remote Sensing and GIS course began by asking students to create place marks of their hometowns.  The students did short presentations to introduce themselves in the context of a place.  The exercise provided a fun and easy first step toward the more powerful mapping tools to follow, such as ArcMap and ArcInfo.  Other faculty and staff at Williams are creating maps with virtual earth software, and posting the files in Blackboard.  Their students enjoy seeing specialized maps focusing on the areas they are studying, and using free virtual earth software means they can view the maps from any computer.

At Wheaton College, Lund saw the same instant engagement among Education majors when they were asked to find virtual earth content to support their lesson plan. There is an enormous amount of spatial information available on the Web.  The universality of Google and the simplicity of contributing data has resulted in a mind-boggling diversity of data in the Google Earth Community archive.

In a GIS course at Massachusetts College of Liberal Arts course, Macklin introduced ArcGlobe (which is not a free download) and students exhibited both comprehension and enjoyment.  They gathered weekly in the lab, outside of class, to spend more than the required amount of time on each assignment.  By the end of the semester, they urged her to add a second course to the sequence so they could continue working on projects with these new tools.

Figure 1:  Santo Domingo
Santo Domingo map is the property of John Carter Brown Library at Brown University.
Satellite imagery provided by Google Earth™ mapping service.

In a Wheaton Hispanic Studies course, Professor Domingo Ledezma set his students the task of bringing some sixteenth century maps in to the present day.  His class visited Brown University to see maps drawn by artists aboard Spanish voyages to the New World.  Back on campus, they downloaded KMZ files from Blackboard to see the hand-drawn maps overlaid on satellite imagery.  Using the "transparency" tool, students matched sixteenth century locations to points in the present-day ports.  They created place marks and translated the "Old Spanish" legends into Modern English.  They expressed enthusiasm for the assignment, particularly the opportunity to contribute to others' appreciation of the beautiful maps they had been privileged to see in the Brown University archives.

Figure 2: Autism prevalence in US 1999-2000
Data provided by the US Department of Education
Satellite imagery provided by Google Earth™ mapping service.

Here is another example from Wheaton College. Professor Grace Baron teaches a first year seminar called "Visualizing Autism." This is one of many maps created in ArcMap, using data provided by the U.S. Department of Education. Having many years of data, she can show change over time. She had used ArcMap in this class before with great success but students were more intrigued when the map was presented on the curved surface of a virtual earth.

Free virtual earth software is a relatively new phenomenon. We asked our colleagues at other colleges how they are using it in the classroom. Many replied that there was interest, but there were few applications at that time. We have compiled a cross-section of examples from the early adopters who shared their experiences with us.

**Spatial Literacy**
Victor Coonin, in the Rhodes College Art Department, takes students on virtual field trips, both locally and remotely. He states, "If you want to talk about Venetian landscape painting or the topography of Egypt, you can visit those landscapes through software like Google Earth and see what they really look like." [1]

Maps engage us in an affective manner. Although nothing can compare to walking the land in multi-sensory reality, virtual earth software is a good deal more convenient, and it does provide an opportunity for psychomotor involvement.  Roving across the map, zooming, panning and clicking on place marks, interactive maps engage us by rewarding our curiosity and passion for discovery.



Figure 3: Northampton, Massachusetts
Map data courtesy of Jon Caris, Smith College
Map overlay courtesy of Smith College
Satellite imagery provided by Google Earth™ mapping service.

When possible, teachers can make maps "real" by having students physically visit the places being mapped.  Jon Caris at Smith College begins his GIS course with an historical painting and a real-life field trip. They look at a landscape painted in 1865, then his class goes to the top of a hill near campus, where they see valley from the same vantage point as the artist. Back in the classroom, the students step back in *time* to look at a map from the same era as the painting. Next, the students step back in *space*, to look at the hill where they recently stood.

Below you can see the 19th century map "draped" over the 3-dimensional terrain to show elevation. Note the white rectangle, with the "Smith" place marker.  This is the viewshed of the 19th century painting.

In this exercise, the students learn the convention of map layers; they also learn to deliberately change their perspective. One can imagine that, after explicitly changing their physical perspective, they would be more aware of the power of changing their intellectual perspective.  By asking them to step back and look at a hilltop they recently occupied, we ask them to create a habit of finding a new angle or juxtaposing different layers of meaning.  It's useful in any field of discovery, and key to the skill of critical thinking. [2]


**Visualizing Data**
We've been talking about reducing the abstraction of space. Caris also uses virtual earth software to reduce the abstraction of data.  Maps are all about numbers.  How far? How big? How many? How high?  When we look at a data table, we see symbols (that is, numerals) which we cognitively translate into quantitative concepts.  On the other hand, when we look at a map, we see colors and shapes that perceptually translate into quantitative concepts such as "bigger", "closer", or "more".  Academia traditionally privileges text and numbers and typically uses images as add-ons to communication done by text or numbers. Edward Tufte gives a powerful argument for using images as a primary conveyance of a concept, and maps are eloquent images when we're dealing with spatial data.[3]

Caris used this eloquence in a "Summer Science" program that Smith College offered to high school students.  Students took GPS units into a forested area near the Quabbin Reservoir to investigate chestnut tree seedlings. Students recorded the locations of seedlings with GPS units, and recorded the height, the number of stems, and also noted whether there were signs of blight. Students downloaded their data into Google Earth Plus, and the instructor combined their points into a single file.

Caris created his own symbol set to represent the variables from the students' data. Seeing their data points in the virtual earth software brought it home to the students that each was individually contributing to an effort larger than herself.  They expressed youthful enthusiasm for the prospect of benefiting the forest they studied, and chestnut trees in general.

Figure 4:  Chestnut tree seedlings in Quabbin Reservoir
Data courtesy of Jon Caris, Smith College
Satellite imagery provided by Google Earth™ mapping service.



Figure 5:  Casperkill Creek
Data and graph provided by Meg Stewart.
Satellite imagery provided by Google Earth™ mapping service.

Student researchers at Vassar College collected and analyzed water samples in a nearby creek. Meg Stewart mapped the results with GE-Graph: Graph for GoogleEarth.[4] This freeware creates graphs that can be exported as KMZ files. Maps give sensory impressions of space and quantity. It's very obvious where the clusters of lower and higher numbers are – we would have had to invest some time to understand this if we had only a table of data.

Claude Javier, a renowned mathematics educator, lamented that teachers largely ignore the cognitive effort that goes into the transformation of a squiggly line (a numeral) into a concept (a number), upon which we can perform abstract manipulations (arithmetic), to generate a new concept written as yet a new squiggly line (the answer) which we then try to transform back into some understanding of the real world. This is a challenge for some people.[5] With the map, however, it is intuitively obvious that a "higher bar" means "higher levels of ammonium".

**Maps as Engaging Narratives**
People love listening to stories. It's in our blood. We remember things better if we encounter them in the framework of a story, and we invent cognitive relationships to support the stories we are hearing. Sometimes those relationships are geographic. David Staley of Ohio State University has his students draw maps to illustrate threads of historical narrative.[6]

Mapping the adventures of heroes like Odysseus, we intuitively raise the fundamental questions of geography such as proximity and accessibility. Are two things near or far from each other? A truism of geography is, the closer things are, the more they influence each other. Yet two places could be close as the crow flies, but on opposite sides of a mountain range or some other physical boundary. Separation is more complex than mere distance, and a virtual field trip can aid understanding.

GoogleLitTrips is a collection of narrative journeys compiled by high school teachers to enhance their students' experiences with their books.[7] Seeing the trip in virtual earth software trumps the map-on-the-wall approach, not just because it's interactive, but also because seeing the land in 3-d relief gives the students a better idea of what the trip was really like:

> What could the travelers see as they sailed into the bay?
> If there had been a battle, would the terrain have impacted the outcome?

Mapping narratives frees us from the chronology inherent in the storyline; it helps us look at spatial questions as well. Academia has traditionally favored linear and hierarchical organization. Organizing things spatially opens up new possibilities of perception by emphasizing proximity and distance.
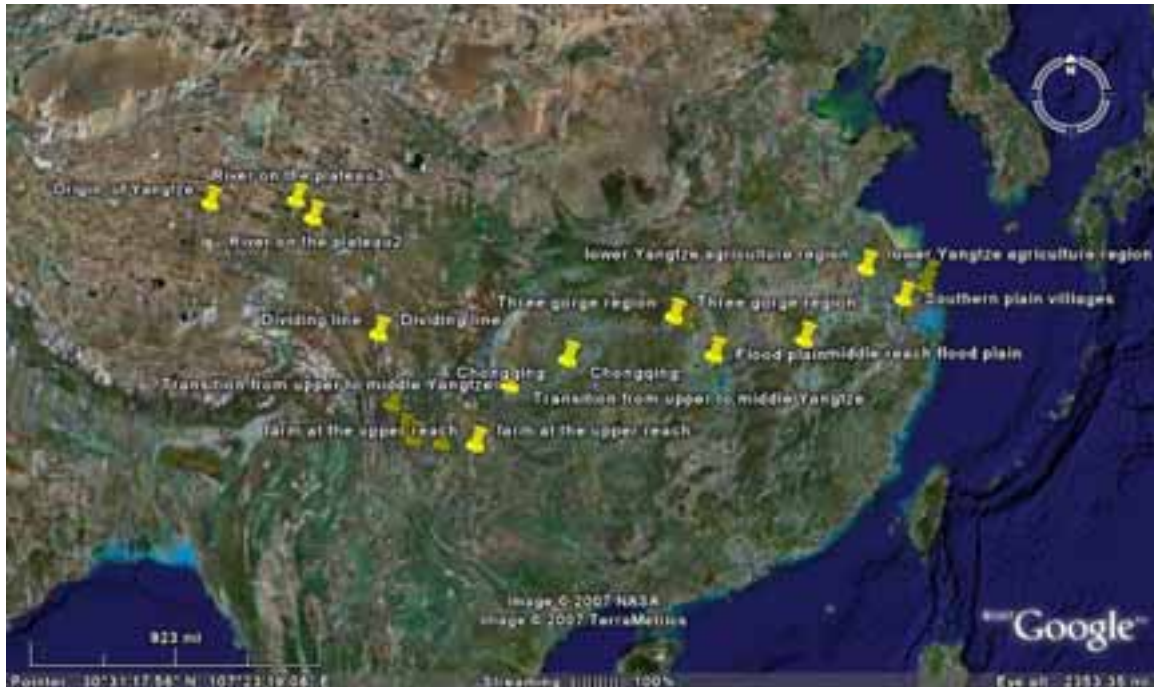
Figure 6: Yangtze River Tour
Annotations created by Yu Zhou.
Satellite imagery provided by Google Earth™ mapping service.

Professor Yu Zhou at Vassar College created an annotated tour of the Yangtze River.[8]
Many of the place marks link to text and image annotations. Note that at a lower
"altitude" one sees many more points than are shown here. This image shows only some
of her many place marks.

Zhou assembled the place marks for her *Making of Modern East Asia* course.  According
to Meg Stewart at Vassar, the purpose of the tour and the various place marks was to
give students a sense of the Yangtze, its meandering path, the terrain through which it
flows, and the different types of geomorphology along the river.  Zhou also asks students
to look at the Panoramio photographs connected to certain locations.  These photos are
contributed to the global earth community by a huge group of users who are usually just
sharing vacation photos.  The juxtaposition of satellite images and snapshots allows
students to see a place in two scales, from above and from the ground. "It's very
powerful," Stewart reports.


**Collaborative Mapping & Critical Thinking**
Google Earth software makes it very easy for a casual user to annotate an image,
marking points or lines or polygons.  It takes about 5 minutes to create a few place
marks and to mail the screen image to a friend (or an instructor).  And it takes about 10
seconds longer to mail the virtual earth file, so the recipient can pan and zoom in the
same virtual environment as the sender.

Classroom collaborations are very easy, as we recall from the story of the chestnut
seedlings. Worldwide mapping collaborations have become quite commonplace.  Below
is a map from the Google Earth Community website.  It identifies the 89 locations
mentioned in Shakespeare's plays.[9]  Some of them are fairly general, like "Padua" or
"Rome", but others are very specific, like Macbeths' castle, or a particular crossroad.
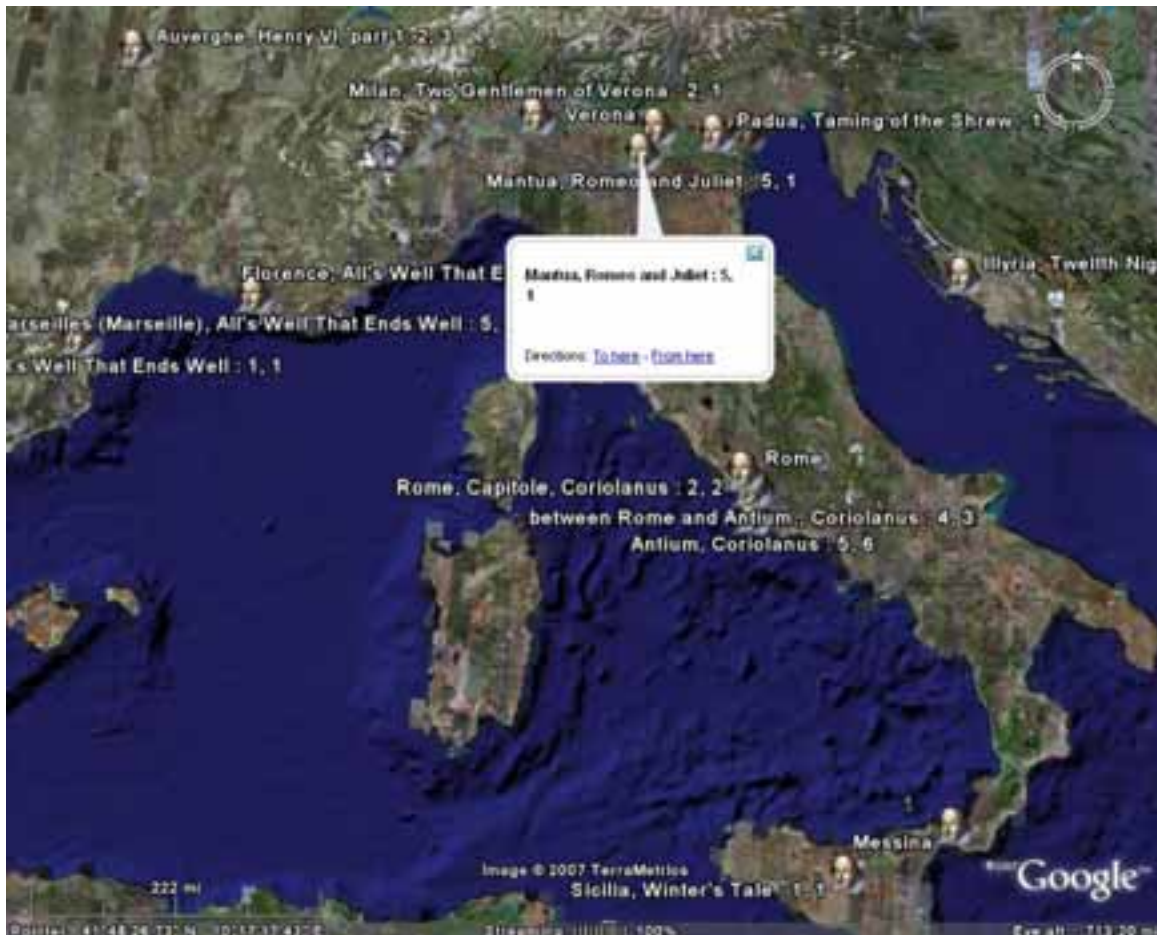
Figure 7:  Locations in Shakespeare's plays
Points contributed by H21 and members of the Google Earth Community, "all the places in Shakespeare's plays."
Satellite imagery provided by Google Earth™ mapping service.

After the initial post there was a flood of input from the Shakespearean community worldwide, some of it quite passionate, with phrases like, "The Forest of Arden is not a fantasy place …This is nonsense."[10]  Most posts are very courteous.  Others are both polite and insistent, such as, "Perhaps you would like to edit your contribution rather than leaving me to place another conflicting site nearby." [11]

The blog beautifully illustrates the rough-and-tumble scholarly debate that we want our students to engage in; it models the critical questioning we want them to bring to their own reading and thinking. We also want students to notice that every person posting to the blog is documenting his or her sources.  When there is a conflict between sources, the reader is left to evaluate the authority and the interpretation of the blogger.

Making maps, annotating maps, and using maps give us the opportunity to teach the habits of critical thinking.  We want students to ask questions like, "who provided this data, where did they get it, and did they have an agenda that might imply a bias?" We want students to ask these questions about any source of information, from the Congressional Record to MySpace. And we want them to learn that a good map will give its sources and other metadata.  After students have tried to layer 2 maps with conflicting coastlines, they understand the need to know about projections and coordinate systems.

**Choosing a Virtual Earth System.**
Virtual earth software is revolutionizing our access to spatial data.  These systems are not "real" GIS because their analytic capabilities are minimal or non-existent.  However, we saw above how instructors are using virtual earth experiences as motivational first steps in their GIS courses.  And we've seen how analytical data can be exported from external packages like ArcMap, and can be shared with non-GIS users using a virtual earth program.

There are now a number of 3-D virtual earth applications, including ArcGIS Explorer, Google Earth, and World Wind.  There are also 2-D mapping applications, like ArcExplorer, Mapquest, etc.  The matrix below lists differentiating characteristics of several programs with free downloadable viewers.

When deciding how to use a virtual earth program, one might look at the continuum of capabilities listed in the matrix below.  The simplest programs simply present a static image; after selecting a specific map **display**, there is no further interaction.  Most programs in the matrix allow the user to navigate through a map; to **zoom, pan and search**.  The more powerful programs let the user **add data layers** to the original map.  Earlier we saw examples of users adding place marks and users overlaying images and shape files.  The most powerful programs provide some analytical capabilities, as well, letting the user **query** and select certain features in a map.  Another important characteristic to consider is the ability to **share** with others.  A user can always send a screenshot, but only certain packages allow the mapmaker to save and send data files and allow the recipient to download viewing software.

Table 1: Choosing virtual earth or map software

| | Display map image | Navigate: Zoom, pan, search, etc. | User can add data layers | Allows user analysis | Users can create & share layers |
|---|---|---|---|---|---|
| **2D Maps** | | | | | |
| CIA – The World Factbook Reference Maps | X | | | | |
| Map Quest | X | X | | | |
| ArcExplorer 9.2 and Java Edition | X | X | Shapefile, raster image | Query | |
| Google Maps | X | X | MyMaps | Simple query | Email URL |
| **3D Maps** | | | | | |
| NASA World Wind | X | X | Limited | | |
| ArcGIS Explorer 9.2 | X | X | KML, KMZ, Shapefile, raster image, Server, File Geodatabase | Simple Tasks | |
| Goggle Earth | X | X | Create points, lines, polygons, animated tours and 3D Google Sketchup models | | Email or post KML or KMZ files |

**Conclusion**

Using virtual earth software can help students become more adept at visualizing space, visualizing data, and thinking critically about maps. It is also a powerful device for bringing distant lands into the "here and now", tying discipline subject matter to reality. An interactive map can connect a learner to a fictional character, a historic figure, an area of erosion, or a remote city. Connection and immediacy help students learn.

We have reviewed applications from four pedagogical categories: spatial literacy, visualizing data, maps as narratives, and collaborative mapping. Academia puts a strong emphasis on regular literacy, quantitative literacy, information literacy and technology literacy. Virtual earth software helps students achieve spatial literacy: an awareness of the importance of place, and the skills to investigate questions of space and place.

We observe that mapmaking encourages critical thinking. With virtual earth software, students become mapmakers after only a few minutes of instruction.  After a student has made a map himself, he is more likely to become more critical of maps made by others, asking questions like, "Who made that map?" "Where did they get their data?"

The approachable interface of virtual earth software is changing how students approach geography, putting it within reach of casual users as well as students of GIS.  When a senior at Williams College was introduced to "GIS Lite" as they call it, she said "Wow, I really wished I had learned about this a couple of years ago so I could have used it in more of my classes!"  Easy access to spatial imagery can enrich students' communication, giving a sense of place to their research and reports.

**Links to interesting information:**
Shakespeare's Plays
http://bbs.keyhole.com/ubb/showfl at.php/Cat/0/Number/155428/an/0/page/0

Crisis in Darfur
http://bbs.keyhole.com/ubb/download.php?Number=796106

Shackleton's Voyage: Diary and letter writing
http://bbs.keyhole.com/ubb/download.php?Number=59202

NSIDC Data on Virtual Globes: Google Earth
http://nsidc.org/data/google_earth/

Lewis and Clark Expedition
http://bbs.keyhole.com/ubb/z0302a1700/sep23.kmz

Iran Nuclear Sites
http://bbs.keyhole.com/ubb/download.php?Number=388329

Vassar College Educational Tools:
http://bbs.keyhole.com/ubb/showthreaded.php/Cat/0/Number/762267/page/0/vc/1

UNESCO World Heritage Sites
http://bbs.keyhole.com/ubb/showfl at.php?Cat=0&Number=38862

2009 eclipse paths courtesy of Jay Pasachoff
http://www.eclipses.info/

Iraq War Map
http://www.obleek.com/iraq/index.html

BBC Map of Iraq War
http://news.bbc.co.uk/2/shared/spl/hi/in_depth/baghdad_navigator/

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[1] Shepard, Martha Hunter, "Tools of the Trade," *Rhodes Magazine.* Summer 2006. Website. Rhodes College, Memphis, TN.  http://www.rhodes.edu/155_1307.asp  Accessed May 2007

[2] Sinton, D.S. and S.W. Bednarz., "About that G in GIS," *Understanding place : GIS and mapping across the curriculum.* Diana Stuart Sinton and Jennifer J. Lund. ESRI Press, Redlands, CA, 2007. pp 35-47.

[3] Tufte, Edward R. 1982. *The visual display of quantitative information.* Cheshire, Conn.: Graphics Press.

[4] GE-Graph: Graph for GoogleEarth. Website .http://www.sgrillo.net/googleearth/gegraph.htm Accessed May 2007.

[5] Janvier, Claude. 1987. *Translation processes in mathematics education.* Mahwah, N.J.: L. Erlbaum Associates.

[6] Staley, David J., "Finding narratives of time and space," Understanding place : *GIS and mapping across the curriculum.* Diana Stuart Sinton and Jennifer J. Lund. ESRI Press, Redlands, CA, 2007. pp 35-47.

[7] Google Lit Trips. Website maintained by Jerome Burg, http://www.googlelittrips.com/.  Accessed May 2007.

[8]  Google Earth Community posting by Professor Yu Zhou of  Vassar College. **"East Asia Geography (Yangtze River)."** http://bbs.keyhole.com/ubb/showthreaded.php/Cat/0/Number/762267/page/0/vc/1  01/19/07 12:35 PM.  Accessed May 2007.

[9] Google Earth Community posting by H21 and others. "all the places in Shakespeare's plays". http://bbs.keyhole.com/ubb/showflat.php/Cat/0/Number/155428/page/0/fpart/1/vc/1  Accessed May 2007.

[10]  Google Earth Community posting by H21 and others. "all the places in Shakespeare's plays". http://bbs.keyhole.com/ubb/showflat.php?Cat=0&Board=modEarthPeople&Number=155428&page=0&fpart=2  Blog entry #191707 - 11/10/05 11:20 AM  Accessed May 2007.

[11] Google Earth Community posting by H21 and others. "all the places in Shakespeare's plays". http://bbs.keyhole.com/ubb/showflat.php/Cat/0/Number/155428/page/0/fpart/all/vc/1 Blog entry #208041 - 11/23/05 02:03 AM. Accessed May 2007.