K2 Geography Arc of Inquiry

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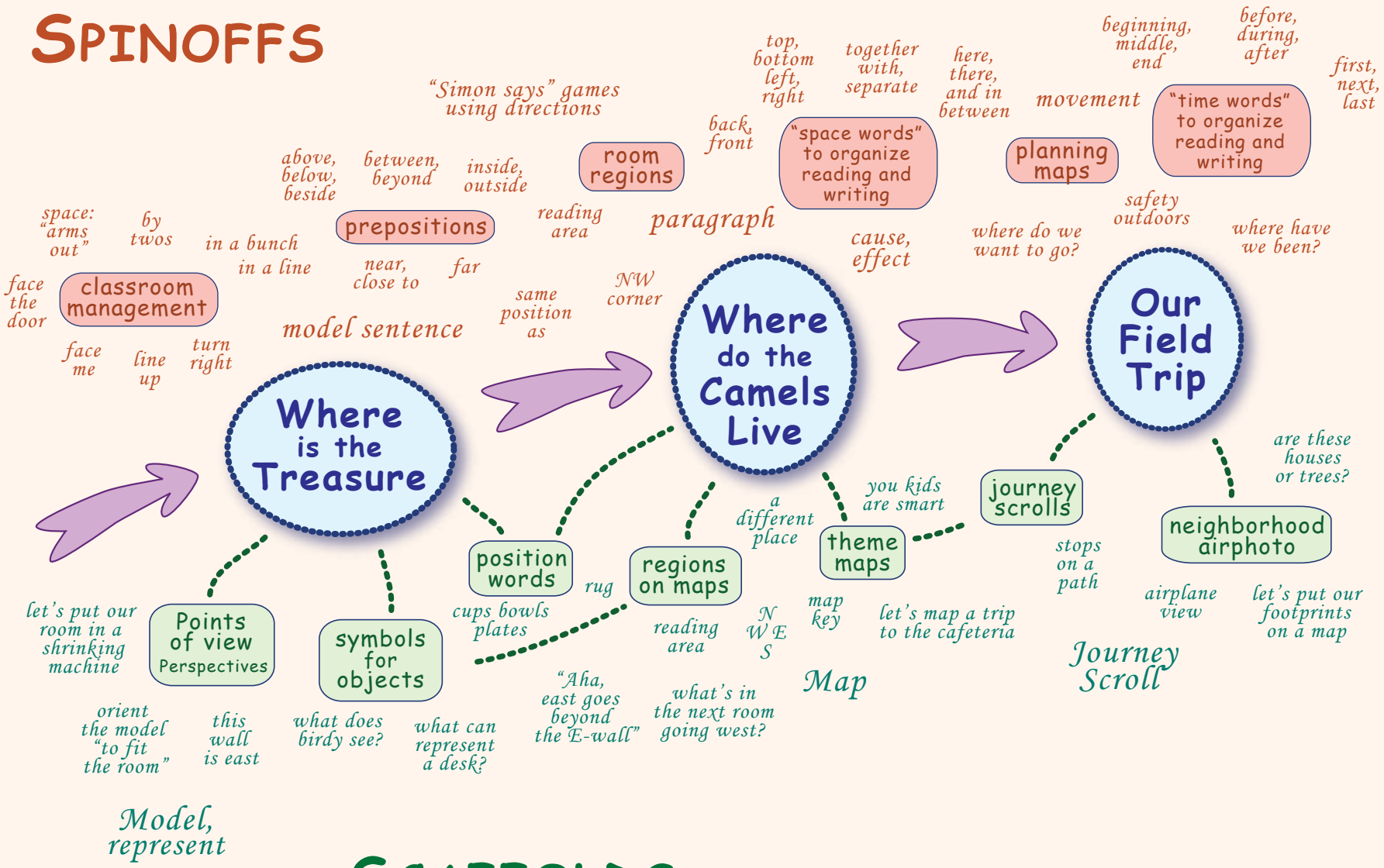


Spatial Thinking in the Human Brain

(a graphic organizer for taking notes)

More than 4000 research studies since 1995 show that the human brain has separate "networks" that do specific kinds of spatial thinking, in parallel and often simultaneously.

Spatial Analogies

Do places in similar positions in other parts of the world also have similar conditions?

AS C IS TO D

Spatial Comparison

How are places similar or different?

SIMILAR

Spatial Auras

What nearby places may be "under the influence" of this place?

NEAR

Regions (Spatial Groups)

What places are similar in some way <u>and</u> located close to each other ?

IN THE GROUP

Spatial Sequences and Transitions

How do conditions change from one place to another?

BETWEEN

ALIGNED, BUNCHED

Spatial Patterns

Why are features arranged in bunches, lines, rings, waves, or other non-random ways?

INSIDE

Spatial Hierarchies

What smaller entities are inside larger ones?

TOGETHER WITH

Spatial Associations

Why do some features occur together in the same places?

Basic Spatial Reasoning

A. Immanuel Kant said it well: *Human brains have "built-in" ways of organizing information: spatially (in space), temporally (in time), causally (by cause-and-effect processes)*

B. Brain-scanning reveals distinct networks that do different kinds of spatial organization:

1. **Comparison** – bigger/smaller, rounder/squarer, darker/lighter, redder/grayer
   Examples: Iowa is smaller than Texas, Poland rounder than Italy.
   China has more dots than Australia on this map.
   Botswana has a darker color than Zimbabwe.

2. **Proximity** - next to, near, close to, within its area of influence (its "aura")
   Examples: cabin near a lake, noisy house near an airport,
   gas station near an Interstate highway exit,
   refugee camp near a country with a civil war

3. **Region** - part of a group of places with something in common
   Examples: farms with corn fields in the Corn Belt,
   abandoned factories in the Rust Belt,
   people speaking Spanish in Latin America

4. **Sequence** - in order, along a line, on the way from one place to another
   Examples: third block along a particular street,
   grassland between rainforest and desert,
   middle-age houses between city and suburbs

5. **Hierarchy** - inside something larger, "place in a pecking order"
   Examples: counties inside state, states inside country,
   creeks inside watershed of large river,
   rivers or mountain ranges inside continent

6. **Analogy** - in a similar position in a different part of the world
   Examples: ports near mouths of different rivers,
   neighborhoods near downtowns of different cities,
   places in similar positions on different continents

7. **Pattern** - arranged in bunches, lines, arcs, waves, or other non-random ways
   Examples: forts in a line, coral reefs in a ring around an island,
   oil wells in a bunch in one part of a country,
   sand dunes arranged like waves in a desert

8. **Association** - tending to occur together with specific other features
   Examples: stoplights at major intersections,
   people with malaria in places with A. mosquitoes,
   earthquakes at borders between crustal plates

C. There are huge individual differences in how people do different kinds of spatial thinking.

D. Studies show that every student can learn to do every kind of spatial reasoning better.

E. An "expert" map reader is able to use more modes of spatial reasoning, and to use each one better, than a novice. That is why a good map reader can get more information, faster and more accurately, than a novice can.

It's like learning how to learn.

An Oriented Globe – A Small Model of a Really Big Earth

Background : Many students have difficulty with the idea of representation – they just don't seem to believe that a one-page map can represent an entire continent (or, in the other direction, that a hand-sized drawing can represent a microscopic virus or even a single atom). Representation seems to be one of those topics that students need to encounter in several different ways before something clicks. This is especially true for a key idea of geography, namely that a classroom globe can represent the entire earth. Unfortunately, students sometimes pretend they understand it, rather than admit that they are baffled by something "everyone else seems to get." It takes some sensitivity to recognize when students don't get it, and some creativity to think of different ways to present what is basically the same idea.

Materials:

- a few models of large and small things – cars, bears, ants, buildings, a tiny doll, and a ball of clay.
- a good classroom globe (preferably in a cradle ring, rather than fixed on a "standard" slanted axis; see Figure 9F in the book)
- OPTIONAL: continents from a decent world map, cut out of foam board, flannel, masonite, etc. (the NY Center for Geographic Learning has some templates in easy-to-print form on a CD)
- OPTIONAL: a model of the classroom (see other activities where this might be useful)

Procedures

- Hold up a model of a car and ask students what it is. Most times, the answer will be simply "a car." If so, try going through an elaborate pantomime of trying to open the door and get in. Then, look baffled, and say "it can't be a car, because a car is something I can sit inside."
- Guide discussion to focus on the fact that a model car is a tiny version of something big enough for an adult to sit inside. It's like a car that has been put in a "shrink-machine" and made small.
- Shift focus to a model of your classroom, if one is available. "This is basically a small model of something that is big enough for everyone in the class to fit inside."
- Try a map of your community (perhaps a bus or subway map?) "It's a paper model of a whole city."
- Orient the globe. An oriented globe is one that has been turned so that your location is "up" and the north pole of the globe points toward the wall that you have designated as "north". In this position, the globe is an especially accurate model of the earth. Read on to see why.
- Insert the feet of a small doll in a ball of clay and stick it on top of the globe (i.e. on New York), facing north (these details are important!!) Then, stand next to it, preferably with the same pose and facing the same direction as the doll (it helps to choose a doll in a distinctive pose – I use a 2-inch plastic cowboy waving a hat, and of course I have a similar hat to wave in the same way).
- Say "this globe is now a good model of the earth; it has a model of a person on it, standing just like I am standing now. So that cowboy standing on the globe is a model of me standing on the earth."
- Quickly add that "Of course, I'm bigger than this doll; and the real earth is way bigger than this globe. But the globe is still a good model, because it IS shaped like the earth."
- Go on to demonstrate how the globe-model can be useful. For example, take a string and stretch it from the doll on top toward some place students might know (Chicago?) Say something timely, like "Suppose [our team] is playing the Chicago Bears. This globe can tell us what direction a plane should fly to get there." Then sight along the string, and point in the right direction. For older children in a multicultural setting, using an oriented globe and a string to figure out what direction to point toward Mecca can be an effective application of the principle.

Learner outcomes:

- awareness of the idea of representation
- (subconscious!) appreciation that approximate knowledge of important geographic relationships is more valuable than precise knowledge of trivial facts about places

Issues to be resolved:

- How to overcome the impression that the earth is basically flat. This may be a bigger issue in rural areas, where students can actually see the horizon, and it does look flat.

Educational Things You Can Do With a Globe

P Gersmehl, Michigan Geographic Alliance pgersmehl@gmail.com

Things you can do with a globe mounted on an axis and tilted at 23 degrees

1. Spin the globe
2. Walk the globe around a flashlight or other light source to illustrate the seasons

Things you can do with a globe mounted on a small pedestal base

1. Look at the globe
2. Bump the globe and watch it fall off of the table and break

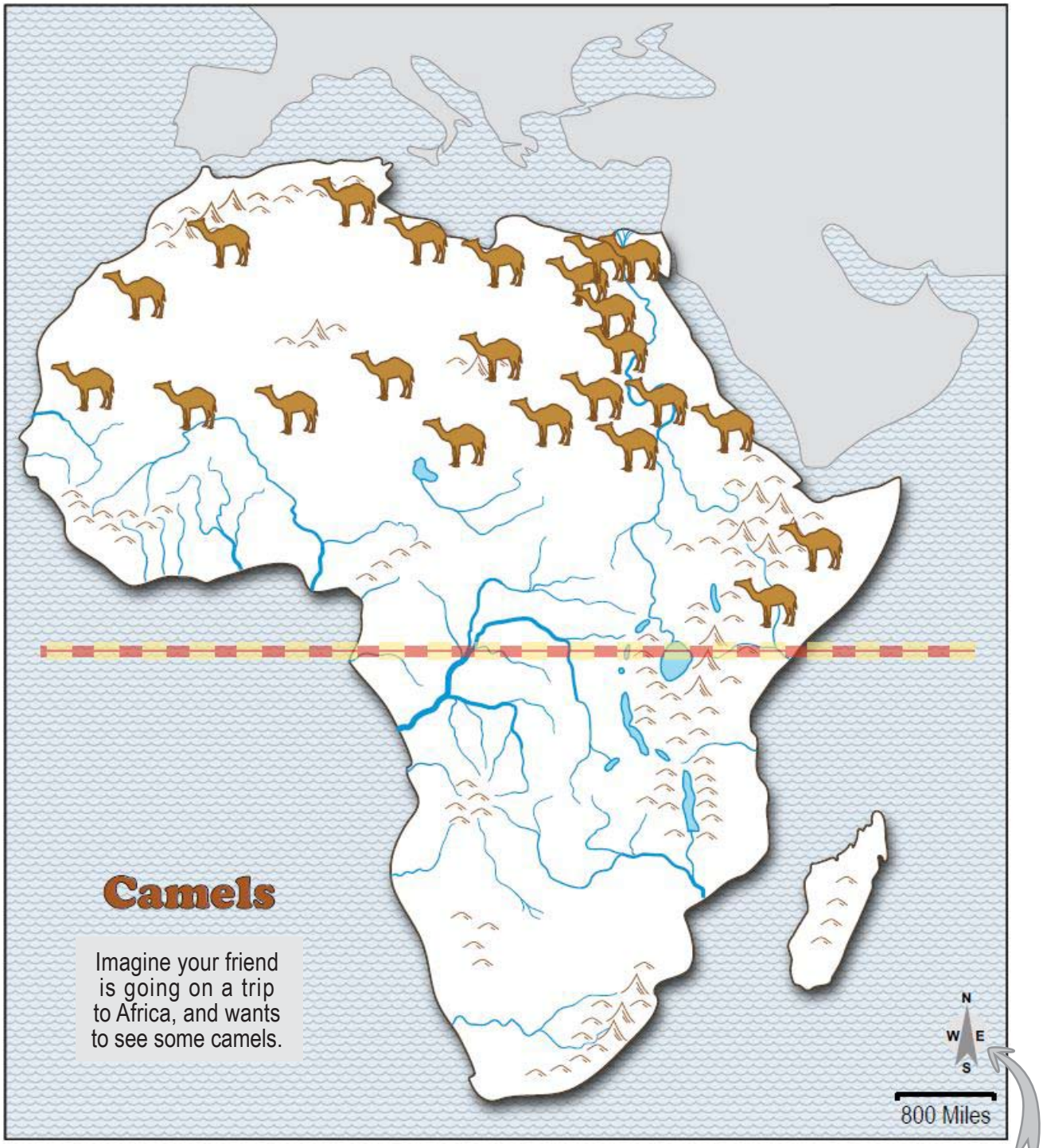
Things you can do with a globe mounted in a cradle that goes roughly around the middle

(This works best with a globe that shows longitude at 15-degree increments, because 15 degrees of longitude is one hour (aha, it's a math lesson, 360 degrees divided by 24 hours).

1. Orient the globe to make an intuitively plausible model of the earth – turn the globe until your location is "up," "on top" and the north pole is pointing toward the north wall of the room. For more impact, put a small doll on the globe facing north, and stand in the same pose next to the globe – "The cowboy standing on the globe represents me standing on the big ball of the earth."
2. Find directions to places, e.g. Mecca – orient the globe as in activity 1, stretch a string from your place (on top) to the destination, and sight along the string
3. Measure distances between places – turn the globe to put both places on the cradle ring. Then read the distance from the scale written on the cradle (see below for how to make a cradle)
4. Measure sun angle on a given date – find the latitude of the direct sun on that date from the Analemma (it's a figure-8 or ellipse graph, usually in the Pacific Ocean). Orient the globe to put your location up. Use a stick to show a direct ray of the sun straight down onto the latitude. Use another parallel stick aimed at your place – that stick points directly to the sun at noon.
5. Measure sun angle on a given date <u>and</u> time (this is quite advanced!) – do activity 4, but position the sun-stick 15 degrees east of your longitude for every hour it is before noon (or west for every hour after noon). Then put another sun-stick parallel to the direct one.
6. Estimate the amount of overhang needed to shade a window on a given date (this is a valuable skill in a time of global climate change and rising energy costs) – do activity 5 with a small model of a house at your location. If you have a piece of cardboard as a moveable roof, you can simulate the proper overhang quite persuasively (with a little practice).
7. Estimate the length of day on a given date – turn the globe so that the latitude of the direct sun is "up" (the ceiling lights then become the sun); look at the latitude of your place and count the number of 15-degree "time zones" that are on the lighted half of the globe.
8. Estimate the length of day on a given date at any place on earth – do activity 6, but count time zones for the latitude of any place of interest. If your hand coordination permits (practice does make perfect!), learn to hold the globe at a specific tilt (read from the Analemma for a specific date), and turn it one 15-degree band at a time, counting time zones as you go.
9. Hold the globe at a 23-degree tilt and walk it around a light source to illustrate the seasons.
10. Illustrate the causes of the Coriolis "Force" that deflects winds and ocean currents from a straight path – this is too hard to explain on one page, but if you really understand the principle you can figure out how to show it with a cradle globe – it's much harder with a fixed mount.

How to make a cradle out of a box. Find a box that is bigger than the globe in two horizontal dimensions and exactly half the diameter of the globe in the vertical dimension. Cut a globe-sized hole in the box. Mark 15-degree increments around the hole – they are one hour each, or a bit more than 1000 miles (since the earth is about 25,000 miles around and there are 24 hours in a day). Better yet, make it out of wood!

Where Camels Live in Africa



(The compass rose tells what direction is "up" on a map.)

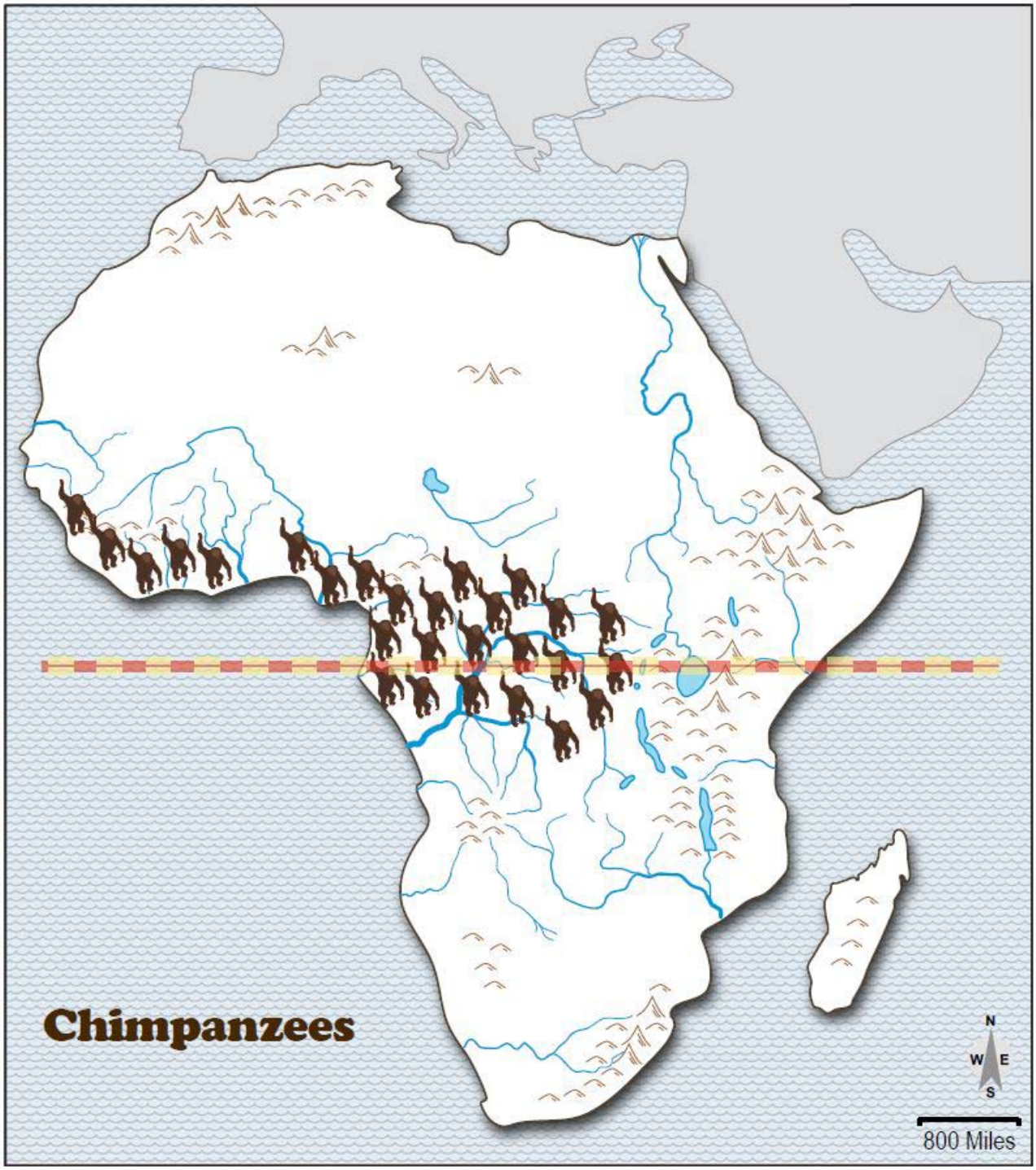
1. Name the "walls" of this map - N, E, S, W.

2. Draw a line all the way around the area where camels live.

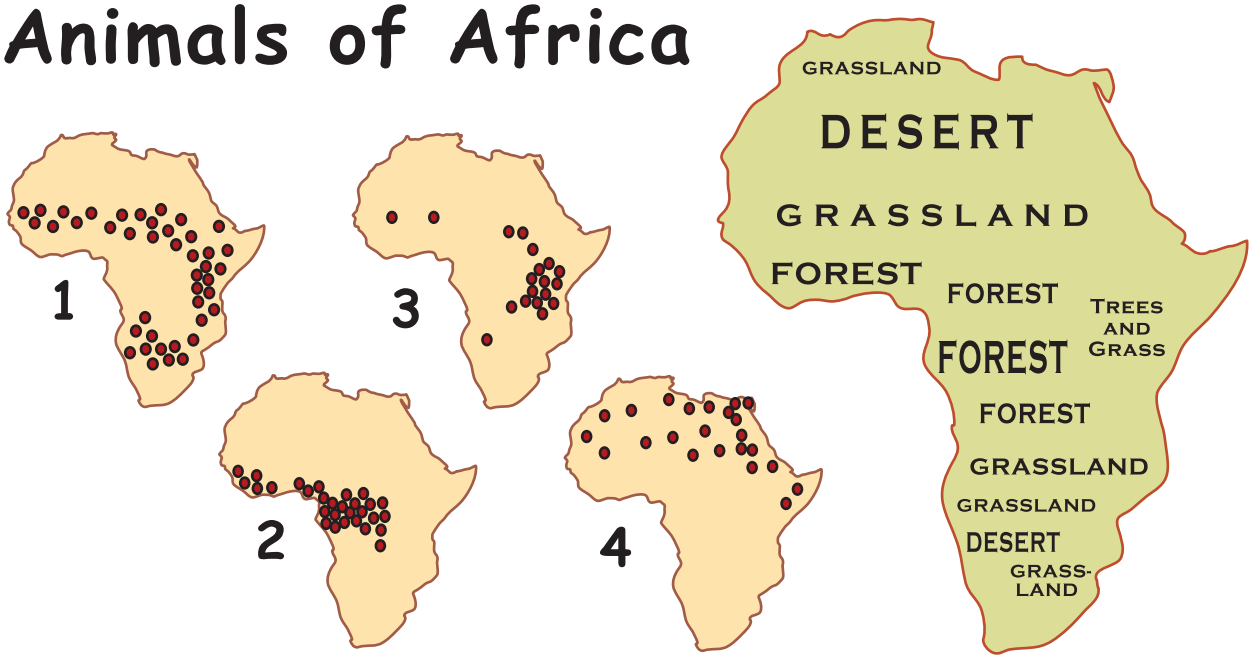
3. Where do camels live in Africa? Circle how you might say it in words:

In the north part In the middle part In the south part

Where Chimpanzees Live



Animals of Africa



The dots on these four maps show places where these animals live: Camel, Cheetah, Giraffe, and Chimpanzee. Write the correct name and map number on the lines next to each description below.

Name	Map	Description
_____	____	I look like a monkey with long arms but no tail. I can climb trees as well as walk on the ground. I like to live in forests that have really big trees. I am afraid of places where lions and cheetahs live.
_____	____	I have a really long neck. This helps me eat leaves from medium-sized trees that grow in grassy areas. I don't like forests that have really big trees. I don't like grasslands that don't have any trees.
_____	____	I have big feet. They help me walk on dry sand. I also have a hump on my back. My body stores fat and water in the hump. That helps me survive a long time in places that do not have much water.
_____	____	I am a big cat. I can run really fast (about 70 mph). That helps me chase antelopes and other animals that eat grass. I don't like forests where other animals live up in trees and I can't run easily.

MI Field Trip Planning Form

1. **Where** are we going on our field trip? _____

2. **How** will we get there? Circle: Walk Bike Bus Subway _____

3. Here are three things I **think** I will see on the field trip:

_____

_____

_____

4. This is **why** I think we will see these things on the field trip:

_____

_____

_____

5. Here are two things I **hope** I will see on the field trip:

_____

_____

6. This is **why** I think we might see these things on our field trip:

_____

_____

_____

Making a Map in your Head

(while reading or listening to a story)

Here's a "trick" to help you remember a story you are reading or listening to. Sometimes it helps to "make a map of the story in your head."

Suppose the story is about going to a mall. Ask yourself three questions:

Where does it start? At your home (school, your uncle's house, . . .)

Where does it end? at the mall.

What did you see on the way? we went past a park (school, big tree, . . .)

Now, you can use the word "between" to show the order of these places as if you put them on a map. "The park is between my home and the mall."

1. **What story** are we reading? _____

2. **Where did part of the story start?**

_____

_____

3. **Where did the people go from there?** (Where did it end?)

_____

_____

4. **What did they pass or see on the way?** (What did they go by?)

_____

_____

5. **Write a sentence** using the word "between" to describe the places in this story. Make sure you show the places in the right order, how they would line up if you made a map of them in your head.

_____

_____

_____

_____

MI Field Trip Journey Scroll

End

STOP 5. Here I Circle: saw heard smelled

STOP 4. Here I Circle: saw heard smelled

STOP 3. Here I Circle: saw heard smelled

STOP 2. Here I Circle: saw heard smelled

STOP 1. Here I Circle: saw heard smelled

Start

MI Field Trip Observations

1. Where am I now? _____

2. I **see** something that is Circle: bigger than me my size smaller than me

(I think) it is: _____

and _____

_____

_____

_____

3. I **see** something that is Circle: purple red orange yellow green blue

(I think) it is: _____

and _____

_____

_____

_____

4. I **see** something that is shaped like a Circle: ball box plate board

(I think) it is: _____

and _____

_____

_____

_____

MI Field Trip Mysteries

1. Where am I now? _____

2. I **see** something that looks interesting, but I don't know what it is. I will describe it as well as I can. When we get back to our room, my description will help us talk about it or ask someone about it.

_____

_____

_____

_____

_____

_____

_____

3. I **see** another interesting thing. I *think* it is _____. I will describe it here, so we can talk or ask someone about it later.

_____

_____

_____

_____

_____

_____

_____

MI Field Trip Reaction Form

1. Where did we go on our field trip? _____

2. How did we get there? Circle: Walk Bike Bus Subway _____

3. Here are some things I **expected** to see on the field trip, and we **did see**:

_____

_____

_____

4. Here are some things I expected to see, but we did **not** see:

_____

_____

5. Here are two things I was **surprised** to see on the field trip:

_____

_____

6. This is the **strangest** thing we saw on our field trip
(and why I think it was strange):

_____

_____

7. This is what I would most like to see if I ever go there again:

_____

_____

MI Field Trip Wishes Form

1. Where would I like to go on a field trip? _____

2. How would we travel? Circle: Walk Bike Bus Ship Airplane Space ship

3. Why do I want to go there ?

_____

_____

_____

4. Here are some people I would like to go along with me on the trip:

_____

_____

5. Here are some things I expect to see there:

_____

_____

6. This is what I would take with me on the field trip:

_____

_____

7. This is what I would like to bring back from the field trip:

_____

_____

READING

depends on several kinds of spatial thinking:

1. Letters are spatial **shapes**: O M P X S
2. Letters face specific **directions:** b d, p q, n u.
3. Letters occur in spatial **sequences**. tar ~ rat
4. Words occur in spatial **associations** (adjective - noun).
5. Words **influence** nearby words ("White-house lawn").
6. Text is a spatial **hierarchy**
   (phrases inside sentences inside paragraphs)

MATH

depends on several kinds of spatial thinking:

1. Numbers are spatial **shapes**: 2 4 6 8 0
2. A number line has a specific **direction**.
3. Numbers occur in spatial **sequences**. **911 ≠ 119**
4. Subtraction involves a **size comparison**.
5. Division is about **size hierarchies**.
6. And geometry is about **shape** and **connections**.

Spatial Thinking, Reading, and Math

Some key empirical research studies, compiled by P Gersmehl, 2021

An, S. 2013. Schema theory in reading. Theory and Practice in Language Studies, 3#1:130-135.

Anobile, G et al. 2017. Spatial but not temporal numerosity thresholds correlate with formal math skills in children. Developmental Psychology, 54:458-473

Barnes, MA et al. 2014. Visual-spatial situation models and ... reading comprehension. Journal of Experimental Child Psych. 119:101–111.

Ben-Shachar, M, et al. 2007. Differential sensitivity to words and shapes in occipito-temporal cortex. Cerebral Cortex 17:1604-1611.

Bergen, BK, et al. 2007. Spatial and linguistic aspects of visual imagery in sentence comprehension. Cognitive Science 31:5,733-764

Besner, D, Risko, EF, and Sklair, N. 2005. Spatial attention as a necessary preliminary to early processes in reading. Canadian Journal of Experimental Psychology 59#2:99-108

Boyer, TW and Levine, SC. 2012. Child proportional scaling: Is 1/3 = 2/6 ? Journal of Experimental Child Psychology, 111:516–533

Bryant, P. and S. Squire. 2001. Children's mathematics: lost and found in space. Pp175-200 in Gattis, M. 2001. Spatial Schemas and Abstract Thought. Cambridge, MA: MIT Press

Burte, Het al. 2017. Think3d!: Improving mathematics learning through embodied spatial training. Cognitive Research 2#1:13

Carreiras, M, et al. 2007. READING WORDS, NUMB3R5 and $YMßOL$. Trends in Cognitive Sciences 11#11:454-455

Cheng, Y-L and Mix, KS. 2014. Spatial training improves children's mathematics ability. J. of Cognition and Development 15#1:2-11

Cohen Kadosh et al. 2008. Are numbers special? An overview of magnitude representation. Progress in Neurobiology 84:132–147

Cornu, V et al. 2017. Visuo-spatial abilities [and] children's verbal number skills. Journal of Experimental Child Psychology, 166:604-620

Davis, CJ. 2010. The spatial coding model of visual word identification. Psychological Review 117#3:713-758

Dehaene, S and Brannon, EM. 2010. Space, time and number: a Kantian research program. Trends in Cognitive Sciences 14#12:517-19.

Dehaene, S and Cohen, L. 2011. The unique role of the visual word-form area in the brain. Trends in Cognitive Sciences 15#6:254-262

de Hevia, M-D and Spelke, ES. 2009. Spontaneous mapping of number and space in adults and young children. Cognition 110:198–207

DeLoache, JS et al. 1999. Multiple factors in early symbol use: understanding symbol-referent relation. Cognitive Development 14:299–312

Diehl, DD et al. 2014. Neural correlates of language and non-language visuospatial processing in adolescents with reading disability. NeuroImage 101:653-666.

Dorn, RI et al. 2004. Learning geography promotes learning math: Arizona's GeoMath program. Journal of Geography 104#4:151-159

Dotan, S and Katzir, T. 2018. Inter-letter spacing and reading performance. Journal of Experimental Child Psychology, 174:13-28.

Eiselt, A-K and Nieder, A. 2013. Representation of abstract quantitative rules applied to spatial and numerical magnitudes. Journal of Neuroscience 33#17:7526-7534

Fernandes, M and Guild, E. 2009. Process-specific interference effects during recognition of spatial patterns and words. Canadian Journal of Experimental Psychology 63#1:24-32.

Fischer, MH. 2003. Spatial representations in number processing: Evidence from a pointing task. Visual Cognition 10:493–508

Frick, A., 2019. Spatial transformation abilities and later mathematics performance. Psychological research, 83#7:465-1484

Garcia, RB, et al. 2014. Visuospatial working memory in children with dyslexia. British Journal of Developmental Psychology 32:17-33.

Georges, C et al. 2021. The importance of visuospatial abilities for verbal number skills in preschool: Adding spatial language to the equation. Journal of Experimental Child Psychology 201:104971

Georges, C et al. 2016. How Math Anxiety Relates to Number-Space Associations. Frontiers in Psychology 7:1401

Gilboa, A. and Marlatte, H., 2017. Neurobiology of schemas and schema-mediated memory. Trends in cognitive sciences, 21#8:618-631

Gilligan, KA et al. 2019. The developmental relations between spatial cognition and mathematics. Developmental science, 22:e12786

Gouldthorp, B, et al. 2018. The role of sequencing in children's reading comprehension. Reading Research Quarterly 53:1–106

Gunderson, EA et al. 2012. The relation between spatial skill and early number knowledge. Developmental Psychology 48#5:1229–41

Gunderson, EA et al. 2013. Teachers' spatial anxiety and 1st- and 2nd-graders spatial learning. Mind, Brain, and Education 7#1:196-199

Hachmann, WM, et al. 2020. The relationship of domain-general serial order memory and reading ability in school children with and without dyslexia. Journal of Experimental Child Psychology 198, article104789

Hegarty, M and Kozhevnikov, M. 1999. Types of visual-spatial representations and mathematical problem-solving. Journal of Educational Psychology 91#4:684-689

Helland, T and Asbjornsen, A. 2003. Visual-sequential and visuo-spatial skills in dyslexia: variations according to language comprehension and mathematics skills. Child Neuropsychology 9#3:208-220

Hinde, ER. "Teaching Mathematics and Language Arts from a spatial perspective." Social Studies Review 47-51

Holmes, J et al. 2008. Visuospatial sketchpad capacity and children's mathematical skills. European Journal of Cognitive Psychology 20#2:272-289

Huestegge, L et al. 2012. Gender-specific contribution of a visual cognition network to reading abilities. British Journal of Psychology, 103#1:117-128

Huttenlocher, J, et al. 2008. Developing symbolic capacity one step at a time. Cognition 106#1:1-12

Kulhavy, RW et al. 1993. Why maps improve memory for text: the influence of structural information on memory operations. European Journal of Cognitive Psychology 5:375-392

Kyttälä, M et al.. 2003. Visuospatial working memory and early numeracy. Educational and Child Psychology, 20, 65–76.

Lafontaine, H and Kolinsky, R. 2019. Reading by extracting invariant line junctions. Journal of experimental child psychology, 183:75-99

Landau, B., Smith, LB., and Jones, S. 1988. The importance of shape in early lexical learning. Cognitive Development, 3:299–321

Link, T et al. 2014. Unbounding the mental number-line – children's spatial representation of numbers. Frontiers in Psychology 4:1021

Lonnemann, J et al. 2013. Spatial representations of numbers and letters in children. Frontiers in Psychology 4#544

Möhring, W et al. 2018. Spatial scaling and numerical understanding in 5-to 7-year-old children. Cognitive Development 45:57-67

Morgan, Get al. 2007. The onset and mastery of spatial language in children. Cognitive Development 23#1:1-19

Nanu, CE et al. 2018. Spontaneous focusing on numerosity in preschool as a predictor of mathematical skills and knowledge in the fifth grade. Journal of Experimental Child Psychology, 169:42-58

Neath, I and Nairne, JS. 1995. Word-length effects in immediate memory. Psychonomic Bulletin & Review 2#4:429-441

Newcombe, NS. 2010. Picture this: increasing math and science learning by improving spatial thinking. American Educator 29-35, 43

Odic, D et al. 2013. Developmental change in number and area representations. Developmental Psychology 49#6:1103-1112

Opfer, JE and Siegler, RS. 2007. Representational change and children's numerical estimation. Cognitive Psychology 55:169-195

Palladino, P et al. 2001. Working memory and updating processes in reading comprehension. Memory & Cognition 29#2:344-354

Parker, AJ et al. 2020. Undersweep fixations during reading in adults and children. Journal of Experimental Child Psych. 192, p.104788

Parviainen, T et al. 2006. Cortical sequence of word perception in beginning readers. The Journal of Neuroscience 26#22:6052-6061

Pazzaglia, F and Cornoldi, C. 1999. Distinct components of visuo-spatial working memory in the processing of texts. Memory 7:19–41

Pernet C et al. 2005. Selective response to letter categorization within the left fusiform gyrus. Neuroimage. 28:738-744

Petit, J-P and Grainger, J. 2002. Masked partial priming of letter perception. Visual Cognition, 9, 337–353

Pham, AV and Hasson, RM. 2014. Verbal and visuospatial working memory as predictors of children's reading ability. Archives of Clinical Neuropsychology, 29:467- 477

Pritulsky, C et al. 2020. Spatial thinking: Why it belongs in the preschool classroom. Translational Issues in Psychological Science, 6#3:271

Ram-Tsur, R et al. 2008. Serial visual tasks [and] reading disabilities: impaired working memory? Journal of Learning Disabilities 41:437-450

Rousselle, L, and Noel, M-P. 2008. The development of automatic numerosity processing in preschoolers: Evidence for numerosity-perceptual interference. Developmental Psychology 44#2:544-560

Rueckl, JG et al. 2015. Universal brain signature of proficient reading: Evidence from four contrasting languages. Proceedings of the National Academy of Sciences, 112#50:15510-15515

Schlaggar BL and McCandliss BD. 2007. Development of neural systems for reading. Annual Review of Neuroscience. 30:475-503

Schoonbaert, S. and Grainger, J., 2004. Letter position coding in printed word perception: Effects of repeated and transposed letters. Language and Cognitive Processes, 19(3), pp.333-367

Sella, F et al. 2017. Preschool children use space, rather than counting, to infer the numerical magnitude of digits. Cognition, 100:56-67

Shaki, S and Fischer, MH. 2008. Reading space into numbers – a cross-linguistic comparison. Cognition 108#2:590–599

Siegler, RS and Opfer, JE. 2003. The development of numerical estimation: Evidence for multiple representations of numerical quantity. Psychological Science 14:237–243

Sokolowski, HM et al. 2019. What explains sex differences in math anxiety? The role of spatial processing. Cognition, 182:193-212

Szwed M et al. 2009. The role of invariant line junctions in object and visual word recognition. Vision Research 49:718-725

Uttal, DH et al. 1997. Manipulatives as symbols: the use of concrete objects to teach mathematics. Journal of Applied Developmental Psychology, 18#1:37-54

van Garderen, D. 2006. Spatial Visualization . . . and Mathematical Problem Solving. Journal of Learning Disabilities 39:496-506

Venneri, A et al. 2003. Arithmetic difficulties in children with visuospatial learning disability. Child Neuropsychology 9:175–183

Vidyasagar, TR and Pammer, K. Dyslexia: a deficit in visuo-spatial attention. Trends in Cognitive Sciences 14#2:57-63

Vinckier, F et al. 2007. Hierarchical coding of letter strings in the ventral stream: the visual word-form system. Neuron 55, 143–156

Waber, DP et al. 2003. Motor sequence learning and reading ability: Is poor reading associated with sequencing deficits? Journal of Experimental Child Psychology, 84#4:338-354

Wood, G et al.. 2008. On the cognitive link between space and number: a meta-analysis. Psychology Science 50:489-525.

Xie, F et al. 2020. Is spatial ability related to mathematical ability: a meta-analysis. Educational Psychology Review, 32#1:113-155

Young, CJ et al. 2018. The connection between spatial and mathematical ability across development. Frontiers in psychology, 9:755

Zebian, Samar. 2005. Linkages between number concepts, spatial thinking, and directionality of writing in English and Arabic. Journal of Cognition and Culture 5#1-2:165-190.

Geography Insertions in Early Math and ELA Lessons

Unit 1. A. The idea of representation

What's this? *A schoolbus* It can't be - I can't get in it. *It's a model of a schoolbus*

A model is a little thing that represents a big thing. It's like we put a big schoolbus in a shrinking machine and made it really little. Learn the word: *represents*.

Here is a model of our classroom. It's like we put this whole room in a shrinking machine. In a couple weeks, we will use this model to hide a treasure. But first . . .

B. Things that change and things that don't

Which doll could represent the teacher? Which one represents a child?

Big one is teacher, though teacher and child chosen as example both have blue dresses. The clothes we wear can change from one day to another; our size doesn't change. No matter what I wear, I'm going to be bigger than name-a-child (at least this year!) Make sentences to compare things that don't change; now do it for things that change.

Unit 2. A. Position words

Plates of different sizes and colors. Arrange, and describe. Describe, and arrange.

Here are some *position words*: Next to Inside Between On top of Underneath.

Make sentences to describe where things are.

We are geographers. We know position words.

Let's stand up and use position words – Simon says, go next to X, between X and Y, etc.

B. What does the doggy see? What does the birdy see?

Stack a small blue plate on a large red plate. Draw pictures of what each animal sees. Doggy *sees a blue plate on top of a red one*. Birdy *sees a blue circle inside a red circle*.

Stand up and make sentences to describe what different animals, people, etc. see.

We will need these words to find the treasure that we will hide in this model . . .

Unit 3. A. Frame of reference

Here is a model of our classroom. It's like we put this whole room in a shrinking machine.

What does this green paper represent? *The greenboard on the wall*. (or whatever!)
What does this represent? *The door*. (Pick obvious features and pictorial symbols.)

B. Using the reference frame

Stand up and line up along the wall that has the door.

Make sentences to describe how we are standing.

Put dolls in the model to represent where those children are standing.

We will need these sentences to help us find the treasure in this model . . .

Unit 4. A. Symbols for features

Here is a model of our classroom. And here is a symbol of our reading rug
(if the rug is distinctive enough, do it like Socrates – what is this?)

Put the rug where it goes in the model. (Likely right in middle – enclosure is processed before proximity in the brain). Really? Is it closer to the window, whiteboard, etc.?

B. choosing symbols

Choose representations of some other prominent features and put them in the model. marble globe. bookcase or cubby wall. Perhaps not desks yet – repetitive similar symbols pose a greater challenge than unique ones, require more position words.

Unit 5. A. Finding a treasure

Here is a model of a treasure. I am going to put it here in the model of our room.

The real treasure is in the same place in the room. Can you find it?
(There are many variations on this idea. Don't do them all in one day! Reinforce!)

Geography in Early Childhood – Summary of Main Ideas

Brains – deep background (You don't talk to kids about this, but it helps to be aware of it.)

Back in the 1700s, Immanuel Kant suggested that the human brain has several built-in ways to organize experience (he called them "a prioris" - in today's jargon, that's "hard-wired"):

temporal (time, history), ***spatial*** (space, geography), ***causal*** (science), ***quantitative*** (math)

Many educational approaches (behaviorism, constructivism, many other "isms") since then have assumed that "the brain is a blank slate," where a person "constructs" knowledge.

Modern brain-scanning, however, reveals that Kant was right – but . . . human brains actually have several networks that "do" spatial thinking. Like muscles in your arm, you use different combinations of brain areas to do different kinds of thinking.

Distances

Measuring a room – using outstretched arms. Measuring small things – paper clips, dolls.

Later: Measuring on a map – string, etc. Still later: on a globe – NYLAs or LANYs.
How far is it from Kalamazoo to Timbuktu? London? Moscow? Tokyo? Rio de Janeiro?

Bonus: Basic ways of comparing distance (more, less, same) use the same brain structures as mathematical reasoning – comparing distances can therefore help lay a foundation for math.

Directions

Two kinds of directions – **egocentric** (left, right, front, back), **geocentric** (N, E, S, W).

Where is the milk? – ask children for directions in a store
(Don't just correct them; go where they say and let them learn by failing!)

Name the walls. Point north. That way is north, all the time. Put this box north of the table.

Bonus: many letters (b-d, p-q, n-u) are distinguished only by the **direction** they face; learning directions can therefore help with early stages of learning to read.

Foundations for understanding

Places are different because of **where** they are. (Later: learn about Conditions and Connections)

"Metacognition" about experience – how is **there** different from **here,** where we live?

Later: Globe as a model of the earth – we're actually standing on a big ball.
(Be careful to orient globe with Michigan up, north pole pointing north.)

Equator is a belt around the middle – it's warm every day. North Pole – cold every day.
In between, it's cold at some times and hot at other times. We call that "seasons."
Later: This line on the map is the equator. Where do monkeys live? Camels? Polar bears?

Maps – spatial analogies

A map is an **analogy** – things are "in the same places" on a map as in a real place.
Kids as young as 4 can learn – with surprising accuracy - that a dot or small picture drawn in a box on paper can indicate the position of an object buried in a sandbox.

Bonus: Learning about maps can help kids form "a concept of representation" – which in turn can help them appreciate that a printed shape on a page can represent a sound or a number.

Shapes

Learn to draw a map from memory?? Michigan calls that a middle-school "expectation," but it is a questionable idea. (For example, North America has many different shapes on maps with different projections - which North America should they learn to draw?)

Better: Recognize details you can name. Describe locations of features in a larger area
Italy is a leg. Michigan is a mitten. Louisiana is a boot. Oklahoma is a pan with a long handle.
More important, teach kids to give their own names to details and then verbalize about general position in a larger area – e.g., a thumb on the east side of our state.

Bonus: Sensing the difference between general and specific can help with many school tasks.

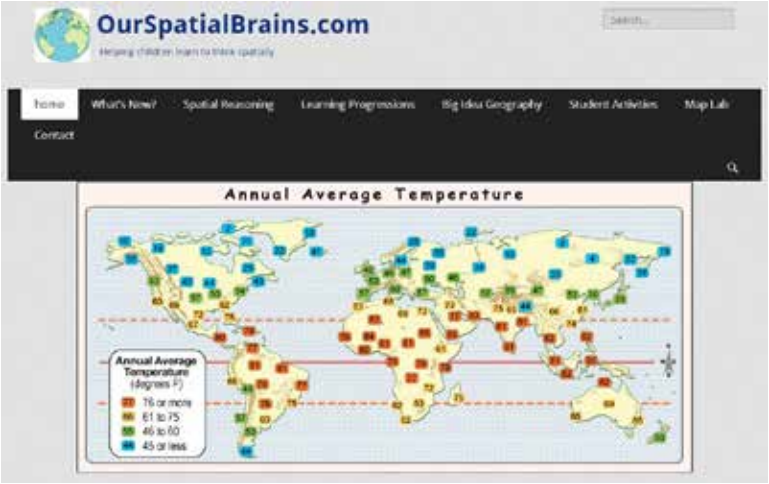
Vocabulary – describing conditions

Prepositions. next to, near, far from, on top, underneath, inside, between, together with

Adjectives. Look at pictures and talk about what it is like there. Infer, not just name!
Rainy, snowy, cold, hot, windy; steep, flat; crowded, empty; old, new; clean, messy

How do geographic conditions influence what people can do? That's the **big** question!

Young Learners Websites



http://OurSpatialBrains.com

Look at
Spatial Reasoning,
to see a research review
and a bibliography
also, . . .
Primary-school geography,
under Activities

http://ss.oaisd.org/

Look at
early grades;
the Grade 3 project
is in its third year
and quite complete;
earlier grades are
still in draft stage

Clickable Maps http://textbooks.wmisd.org/GeographicBigIdeas.html

Look at
each World region map
has several layers
(like the camel map)
designed to support activities
that scaffold map skills
also
the Michigan map
to see examples of maps
that can be used in activities
for elementary students

Gersmehl, P.J. and Gersmehl, C.A., 2007. Spatial thinking by young children: Neurologic evidence for early development and "educability". Journal of Geography, 106(5), pp.181-191.

access at: https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.576.8614&rep=rep1&type=pdf