Teaching Geography with Terrain Models

In 1994 I wrote a self-published book about teaching geography with terrain models. I had been developing, experimenting, and teaching with terrain models for some twenty years as of 1994, and the book reflected my thoughts and teaching practice up to that point. It had become standard practice for graduate school students and for teachers in my geography workshops to sculpt their own terrain models out of plasticene to use with their students. Likewise, making maps of terrain models had become an essential bridge activity for students to transition from terrain models to maps.

Twenty-five years later, in 2019, my practice and pedagogy have evolved. The plasticene terrain models have been replaced by vacuum molded plastic models. Students no longer make their own maps; instead they use maps of the plastic model as seen below. Teachers no longer must spend hours sculpting their own terrain model or making their own maps. Those who wish to can still make their own models and maps, and there is certainly great value in doing so for those who are so inclined, and whose time permits. However, the
molded plastic terrain model and accompanying maps make experiential learning in geography available to a much wider field of teachers and students.

In the earlier decades of my work with terrain models, I would have considered giving teachers pre-made terrain models and maps a heresy. But experience has a way of forcing a constant reconsideration of practice. My own field of experience widened considerably through my work with the 4th and 5th grades of PS 59, a New York City public elementary school. This work required me to experiment and adapt in order to use terrain models and maps successfully in an urban public school with larger classes and limited time frames.

My work in Nepal with the teachers and students of the Rato Bangala School and with the Kamane Academy further challenged my practice and forced me to adapt and develop my materials and my approach to using terrain models and maps with teachers and students. Plasticene modeling clay is difficult to obtain in South Asia, and there is a limit to how many pounds of clay can be brought on the plane, or shipped, to Kathmandu. My last trip to Nepal in 2018 convinced me that I must develop a light, pre-made terrain model.
My work with adult students at Bank Street College and City College has allowed for plenty of experimentation with terrain models and maps and has further helped my teaching practice to evolve. It is difficult to fit map making, and impossible to cram model making, into the fourteen sessions of a college level social studies education course. Again, teaching experiences forced me to reconsider and reshape my teaching practice in order to make sure terrain model work was more than just a graduate school experience, that it could actually be used by teachers-in-training in their future classrooms.

As this new edition of *Geography through Terrain Models and Maps* reflects the evolution of my teaching practice, it also reflects an evolution of technology. I am now able to locate and place digital photos within text in a way that was not available to me in 1994, and this edition is richly illustrated with photos that I’ve taken with adults and kids, often as I worked. Moreover, my experience using terrain models in these disparate venues adds to the my belief in the applicability of this teaching practice across age groups, genders, socio-economic groups, and across cultures.
Although aspects of my work with terrain models and maps have changed, my commitment to working with three-dimensional models to teach geographic concepts and map reading skills has remained. As unchanged is my belief that work with terrain models is not just a niche curriculum for private schools, for progressive schools, or other privileged educational settings. All students can and should benefit from this kind of progressive, hands-on work, no matter how limited the school budget or impoverished the neighborhood. I hope this new edition of *Geography, Maps, and Terrain Models* will be illuminating and helpful to my adult students, pre-service and in-service, so that they will be more able to bring terrain models to their classrooms.
Premises: Concrete operations

Terrain models and maps can be used with all ages, from pre-K through adulthood, but how they are used necessarily varies according to age and stage. This particular terrain model and map curriculum is intended for teachers of upper elementary students, 4th through 6th grade. The elementary school years are a time when concrete thinking dominates, and abstract thinking is just dawning. These are the years when a child relies heavily on using concrete materials and operations, be they manipulatives in math, experiments in science, or terrain models in geography. Sadly, these are also years in which students are often expected to reason with inappropriately abstract symbols in their school work. It is the belief of Progressive educators that, during the elementary school years, experiential learning is necessary to ground symbols, be they mathematical or cartographic, musical or scientific, in experiences and operations with concrete objects. It is the further belief of Progressives that elementary school students deprived of the opportunity to use concrete, manipulative materials, whether in math or maps, will later be limited in their ability to reason with abstract symbol systems. The following anecdotal accounts illustrate how reasoning with symbols is built upon reasoning with objects.

Experiential learning in Math

A group of fourth grade students in a New York City public school is attempting the “do-now” on the board as they enter their math period. The “do-now” reads:

“There are four zoo-keepers who are feeding 16 seals. Each seal can eat three fish. The zoo keepers want to make sure that each of them carries the same number of fish. How many fish will each zoo keeper need to carry to be able to feed these seals?” Virtually none of the children could do the problem. Many tried to add numbers, some multiplied. Others tried subtraction.

“What goes into what?” one girl answered when the teacher suggested division might help. Another student multiplied 4 (number of zoo keepers) by 16 (the number of seals) and got 66.

“Is it right?”
“66 what’s?” the teacher asked.

“Seals?” replied the boy, hopelessly lost. These children were not reasoning with numbers; they were pushing numbers around in a hopeful but random fashion, applying abstract calculations to situations they had not experienced and could not visualize. Nor were they encouraged to discuss their work with each other. Had these children access to objects, had they been able to freely manipulate concrete materials like bottle caps and egg crates, and had they been encouraged to work together with those materials, and time to experiment with these objects, many would doubtless have been able to solve this problem through concrete operations.

Assuming that students had access to manipulative materials and were encouraged to use them to solve problems, the teacher might ask, “How then do children make the transition from concrete operations to written calculations with numbers?” Shouldn’t children who solve problems with objects learn to express on paper the multiplication of 16 seals times groups of three fish? Shouldn’t students be able to calculate the giving out of 48 fish to four zoo keepers through division? The answer is yes! Children should be taught to do paper and pencil calculations in mathematics, but in order for students to know when to use which calculations, when to divide, when to multiply, etc., in order for them to reason with symbols, they must have opportunities to reason with concrete materials. Should this connection between concrete operation and symbolic expression be skipped, students will be reduced to random guessing, unable to reason abstractly with numbers. At best they will be able to follow calculation procedures like borrowing in subtraction or carrying in multiplication, or plugging numbers into formulas.

**Experiential learning in Geography**

In a fourth grade social studies class the study is about ancient Egypt, and the teacher stands before a wall map of Egypt. Individual students have approached the map and located Cairo, the Mediterranean Sea, and the Nile River.

“Why did ancient writers talk about ‘the gift of the Nile?’” asked the teacher. Here was an open-ended question that asked the students to interpret, to solve a geographic problem through looking at a map.
“Because it brought water to Egypt?” responded a student, hesitantly.

“Right, and where does the Nile’s water come from?” the teacher asks, feeling encouraged that his students are thinking about the problem correctly.

“From the Mediterranean Sea?” responded another student, tentatively. The teacher, sensing his Socratic method was running awry, tried to redirect the current of the lesson with a few more questions:

“What kind of water is in the Mediterranean, fresh water or salt?”

“Salt?” ventured one student.

“Yes, because it is connected to the Atlantic Ocean,” the teacher continued. “So the salt water from the Mediterranean Sea flows down into Egypt?” the teacher asked, hoping this reflection would reveal the impossibility of the student’s answer.

“Yes.”

“And that is the gift of the Nile?”

“Yes, Mediterranean gives water to the Nile, and the Nile gives water to Egypt.”

“But what does Egypt need salt water for?”

“Fishing?” suggested the student hopefully.

The confusion of the student is total. The existence of the north-flowing Nile, rolling down from the mountains of Ethiopia, Burundi, et. al. to the south, and emptying its fresh water along the farmlands of ancient Egypt’s lower kingdom, to the north, before exiting into the Mediterranean Sea, was inaccessible to the student, hidden by the very maps that were intended to convey the information. As with the “do-now” about feeding the seals, these students of Egypt were unable to reason because the map’s symbols were disconnected from concrete experience.

Which geographic symbols hid their meaning from students in this situation? In order to solve the problem of the “Gift of the Nile,” students would need to
know that rivers flow from higher elevation to lower, and that they disregard compass direction entirely. In order to conceive of the Nile flowing from south to north, students would have to understand that the lower part of a wall map may be higher in elevation than the upper part of the map. They would need to experience the difference between up and down, north and south. They would need to be able to trace the sources of a river system to mountainous regions, and they would need to understand that water exits, not enters, the mouths of rivers. And if they were to continue to look into the geographic significance of the Nile for Egyptian society, they must apply what they know about seasonal melting to the sources of the Nile, the great floods on its banks, the agriculture practiced in concert with those floods, and the division of labor necessary to practice the agriculture which gave rise to Egyptian society.

Without some concrete experience with elevation, compass direction, and river behavior, these students of ancient Egypt, like the math students mentioned previously, are reduced to a kind of hopeful but random guessing with symbols that hold no meaning for them. In the absence of experience with rivers, the blue line of the Nile on the wall map may as well represent a pipe that conducts water from the kitchen sink of the Mediterranean Sea down into the receptacle of Africa. Again, as in math, if these children had been given access to objects they could freely manipulate, concrete materials like a terrain model, water, blue dye, a pointing stick, and a magnetic compass, and time to work together and experiment with these concrete materials, they would doubtless have been able to bring reason to bear on the question of the meaning of “the gift of the Nile.”

Again, the teacher might ask, shouldn’t children who have come to appreciate the relationships of terrain, lakes, rivers, and oceans on a three-dimensional terrain model come to appreciate these same relationships as expressed symbolically on flat maps? Again, the answer is yes! They should. The guiding principle of this geography curriculum is that in geography education, children should have experiences with a 3-dimensional model before the introduction of flat maps. 3-D models should be used to develop geographical concepts and nomenclature before flat maps, which are based on those concepts, are introduced. When flat maps are introduced, it is especially effective if the symbols on the map should correspond to features on terrain model. In this way,
students can easily forge connections between concrete objects on the model and the symbolic language of a flat map.

My aim in this little book is to describe how to use the terrain model and its corresponding activities with maps. Nevertheless, this book is not a set of lesson plans, rather it is an explanation of a teaching method, the *discovery* method, described by Lucy Mitchell, Jerome Bruner and many others:

The concept of **discovery learning** implies that students construct their own knowledge for themselves (also known as a constructivist approach). The role of the teacher should not be to teach information by rote learning, but instead to facilitate the learning process. This means that a good teacher will design lessons that help students discover the relationship between bits of information.

[https://www.simplypsychology.org/bruner.html](https://www.simplypsychology.org/bruner.html)

In order for the reader to understand the character of the teaching and learning that takes place around a terrain model, I have chosen to present large sections of the dialogue which occurs throughout these activities. The dialogue is not so much a transcription of any one session, but more of a conflation of many sessions with various groups of fourth and fifth graders, graduate students, and teachers, sessions which, in my judgement, best illustrate the discovery learning method with terrain models. The dialogue will be complimented by commentary and photographs, but, I believe, nothing speaks of classroom experience in real time like dialogue.
Working with the terrain model

Room set-up: It is important for all students to easily see and discuss the model and so I arrange the students in a horseshoe around the model while I sit with them with a bucket of blue-dyed water, a pouring beaker, and a dowel rod for a pointer. I prefer to work with half groups and have the other half do seat work and then change and work with the other half group.

When I can’t split the group, I seat the students in a double, or even a triple horseshoe. This class of 5th graders from PS 59 had 33 students. Some sit on the floor, some sit on a ring of chairs, and some sit on a ring of tables behind. Students in the back row may have to step forward to point, but the dowel rod enables all students to participate. It is important that students do point so that classmates know what exactly what they are referring to. Pointing with a finger can block the view of others.

I have found it useful to order landforms into three groups, terrain, rivers, and coastline with one lesson on each group of terms. Terrain has priority because the drainage pattern of rivers depends entirely on the contours of the terrain. Rivers follow terrain, physically, and so we study them after terrain. Coastline comes last. As students are seated around the model, there is much excited talking, pointing, often questions, “What is it?” “Are they mountains?” I put the terrain landforms list on an easel or on the wall nearby, within easy sight of everyone. In this picture I’ve set up for the second lesson and so river terms have been added to the landforms list.
Terrain Landforms

I introduce myself and the terrain model and tell the students that we are going to use the model to learn some geography. We begin by pronouncing the terrain landforms, in unison. We do not define the terms, only pronounce them, so that as we study, the sight and sound of the words is easily available to us. I point out that the comma separates synonyms. Each time there is a comma, I point to it and they say “synonym” (sin-o-nim), or “synonymous,” or just “same.” The list of terrain terms varies with the age group, but this is a fairly standard one:

**Terrain**

- mountain
- mountain peak, summit
- slope (steep or gentle)
- ridge
- pass, gap
- mountain range
- valley
- canyon, gorge
- mesa
- butte
- plain
- plateau

“I see mountains!”

“We are flying in a plane and looking down on the land,” I say to the students. I want to set the scene and address scale in the most general way, only as much as helps the students see the model as a replica of earth seen from a great distance above. “What do you see when you look out the window?”

“I see mountains!”

“I see snow on top of the mountains.”
“I’m pointing to a mountain peak,” I announce, pointing with the stick to a prominent, snow-covered peak near me. Then I pass the stick to the student on my left. “Now you point to one, and say the term.” The student to my left doesn’t hesitate at all and points to another prominent, snow-covered peak. I remind her to say the term, and she glances up at the chart, reassuring herself that she’s saying the right thing.

“This is a mountain peak,” she says.

“Good, now pass the stick.” She passes the pointer to the next student in the ring. He quickly finds another mountain peak. I remind him to say the term out loud. I want to reinforce the connection between their understanding of the physical place, the written term, and the spoken word. I ask him to pass the stick, and one after another students point to various snow-capped mountain peaks. I encourage them to use the synonym too. Eventually, the snow-capped summits have all been identified, and the next student, hesitates.

“There’s none left.” This student seems dismayed, confused.

“Do they need to have snow on the top to be mountain peaks?” I ask, trying to steer him toward any number of lower peaks which are not snow-covered. Still he hesitates. He seems to be afraid of getting it wrong. “You can pass to the next in line, if you aren’t sure, and then you can get your turn back when you are ready.” He passes the stick.

The next student points at a prominent but un-snowy peak, questioning, not asserting. “This one?” I remind her to say the term. “Is this a mountain peak?”

“Yes, but make it a statement, not a question.”

“This is a mountain peak?” A statement, but still tentative. Like a swimmer caught in tide, I work hard against the students’ fear of ‘getting it wrong.’ I want to create a learning environment where students feel free to explore, to take intellectual risks, to make educated guesses. Again, I affirm that she is correct. She passes the stick, and the next student confidently points to a peak without snow.
“So mountains don’t have to have snow on their peaks? There can be snowless mountains?” I ask.

“I think so,” says the student. Several students likewise choose and point to the lower, snowless peaks before I remember the student who passed up her turn. I ask her if she is ready to take her turn, and she nods, takes the stick from a student down the line, and readily points to a lower, rounded peak with no snow on top.

“This is a mountain peak,” she says. When enough of her peers had pointed to snowless mountains, she felt confident in pointing to a snowless mountain of her own. It is worth commenting on the learning process here. Students observe the teacher pointing to a mountain peak and to classmates pointing at other peaks, and they generalize, internally, “If those are mountain peaks, this must also be a mountain peak.” When students “generalize,” they are looking for shared characteristics, similarities of shape, color, or perhaps other shared characteristics, like snow. This kind of thinking, generalization, happens internally, automatically, nor are students aware that they are looking for shared characteristics. Learning is refined and broadened when a characteristic, “snow-covered” in this case, is revealed to be “not essential” in the definition. Mountains should be high, but they needn’t be snow-covered.

This generalizing is spontaneous, naturally-occurring in humans. It is considered, in Bloom’s Taxonomy, to be one variety of higher level thinking. It can be taught only in the sense that it can be encouraged, or it can be discouraged. These lessons with the terrain model explicitly encourage students to observe and to generalize in order to learn. Fear of making a mistake will inhibit a student’s natural inclination to generalize, and that is why I work so hard to create a free and nonjudgemental atmosphere in the classroom.

In due course students point to round top mountains, mountains that look like teeth, and pointy top mountains. As with snow, shape is not an essential characteristic of mountains. Students seem to spontaneously accept that mountains come in various shapes. Nevertheless, when someone points to a mountain with a flat top, some students balked.

“How can that be a mountain? It has no peak,” one student argues.
“Can you have a flat top mountain?” someone asks. The discussion goes back and forth, but the students ultimately want to know what I think.

“If a map maker called a flat top mountain Mount Marcy, you could consider it a mountain. If the map maker called it Buffalo Butte, then you’d call it a butte (byoot).

“What’s a butte?”

I point to the word *butte* on the chart. “It’s like a small flat top mountain.”

“Then what’s a *mesa*?” a student asks, referring to the synonym next to butte on the chart.

“Does anyone know what *mesa* means in Spanish?” I know there are several Spanish/English speakers in the room.

“Table!” a girl calls out excitedly.

“So what does *mesa* probably mean?” I ask.

“Flat like a table top.”

“Is it like a butte?” a student asks.

“Well, the difference is that you can walk around the base of a butte,” I answer. “A mesa is flat on top, like a butte, but you can’t walk around a mesa.” There can be some direct instruction within the context of a discovery-based lesson. When students can’t “discover” an idea or some information, in this case the distinction between *mesa* and *butte*, it seems appropriate for me to provide it.

“How about the next person point out a butte, and when we run out of buttes, we can find mesas.” Students cannot locate another butte, that is, there are no other flat top mountains that you could walk around. Instead, they locate some mesas, which are, by nature, less self-contained than the butte. In the end, I am more interested in the active process of learning than I am with differentiating buttes and mesas. The students seem to be actively engaged in figuring out which landforms are which instead of sitting back waiting to be told. Instead of keeping their heads down, hoping to avoid being called on, they seem to want to participate, to have their turn pointing with the stick. Perhaps their fears are being
allayed because of the nonjudgementalism of the room and the attractiveness of the activity.

I decide to move on to “ridges.” I move the pointing stick along the high, prominent ridge that is nearest me. “This is a ridge,” I say, “It’s the fourth term on the chart.” I want them to see the written word as well as speaking and pointing.

“What’s a ridge?” someone asks

“You need to figure it out.” I say. “Watch what others do before your turn. You have to move the pointing stick along the ridge to show it, sometimes from peak to peak,” Then I pass the stick to whomever was next in the circle.

The first student finds a ridge and asks, “Is this a ridge?”

“Make that into a statement, and you’ve got it.”

“This is a ridge.”

“Run your stick all the way from peak to peak, it can all be part of the same ridge.” The student runs the stick along, and I repeat his earlier assertion,

“That is a ridge, Tom’s Ridge.”

Naming landforms after the person who “discovers” them is a tradition in geography which students often enjoy. Each student, in turn, points out a ridge and repeats the statement, sometimes with a reminder from me, “This is a ridge.” Some students name their ridges after themselves. I prefer to hear a word used in a sentence, even the simplest one, “This is a…” Learning the definition of a word has little value compared to learning to use a word properly in a sentence, and repeatedly using landform terms in sentences reinforces the link between the spoken word, the written word, and the shape of the landform. Eventually, a student points to a ridge that slants up from a valley to a high, snowy peak.
“Can this be a ridge?” The student has run out of ridges which connect peaks.

“That’s a fine ridge,” I exclaim. “Mountain climbers could climb up from the valley all the way to the summit by walking along that ridge. Run your stick along it and try this sentence, ‘We walked up the ridge to reach the summit.’” The student repeats the sentence as she runs her stick up the ridge to the summit. Knowing how and when to use a word in a sentence goes beyond mere identification of a term, it gives student the ability to communicate to one another about what they understand. “Can the next people in the circle find routes from a valley up to a summit? And when you do, use the sentence that Daniella used. I write the sentence on the board, “We walked up the ridge to reach the summit.” You could also add your name to the ridge, if you want. Like, “We walked up Daniella’s Ridge to reach the summit.” I write that sentence on the board too. There are many opportunities for teachers to use the terrain model to advance literacy goals alongside geographic goals, as you work with a terrain model.

As they looked up at the sentence on the board, students identified ridge routes to summits, and they very much enjoyed naming geographic features after themselves the way, historically, explorers have done. I notice on the chart that we had not yet pointed to slopes. I explain that slopes can be “steep”, or “gentle,” referring to the adjectives on the chart.

“This is a steep slope,” I say, running my stick down the side of the first mountain I identified when we began. “This is a gentle slope,” I say, pointing nearby. I write the sentences on the board:

“This is a steep slope.”

“This is a gentle slope.” I ask the students to say the sentences in unison.

“You can point to either one, steep slope, gentle slope, but remember to say the sentence as you point.” I pass the stick to the next in line. The sound of the sentences accompanies the pointing out of slopes, and students seem to enjoy the repetition of the pointing and the speaking. By now we’ve gone around the circle several times, and students seem to be into the rhythm of the lesson. Then a new problem presents itself.
“This slope starts out steep, but it gets gentle,” one student says, pointing.

“Great observation,” I respond. I write the sentence on the board, with the comma in place. I ask the students to read the sentence in unison, just as they did with the previous sentences.

“This slope starts out steep, but it gets gentle,” This compound sentence, showing contrary motion, requires the conjunction “but” preceded by a comma. The repetition of the sentence pattern is probably more important than the formal grammatical terms about conjunctions and contrary motion.

“There may be other slopes that start out steep,” I add, “but then become gentle. Or, if you are moving uphill, they may start out gentle and become steep. As the next people take their turns, perhaps you’ll find more of these steep to gentle slopes and say the sentence as you point them out.” There is more pointing out of slopes, steep, gentle, and mixed to the accompaniment of the corresponding sentences. I’m ready to introduce a new term.

“Next, we need to find the valleys.” I point to one, moving my stick to show the whole area of the valley. “This is a valley. Maple leaf valley, because, to me, it looks like a maple leaf. The valley really includes all this land, the slopes of these mountains, the slopes that come off this ridge, and the bottom of the valley here.” I pass the stick to the next in line.

“I think this could be a valley,” Felicia says.

“Move your stick to show all the slopes and the bottom of the valley.” Felicia moves the stick around, pointing out the slopes as I did. “You can name it too, after what it looks like.” Felicia hesitates on the naming, and students begin to call out names.

“Curvy Valley.” The valley does curve like a crescent.

“Sleepy dog Valley,” says another student.

“Banana Valley.” Felicia decides on Banana Valley. The next student hesitates.
“Could this be a valley?” The shape is very different. It is a low area of the model, where the peaks and ridges give way to a few buttes and low hills and a wide flat bottom.

“I believe you’ve found Death Valley,” I say. “There is no rain at all there. It is a desert, and people have become lost there and died, hence the name.” This sparks some discussion about lost people, a recent news account of a woman lost in the desert for weeks before she was found. The model has become a stage for the fears and fantasies of the students; the geography has become utterly believable.

“There is one more valley, Valle Grande,” I say, again mixing some direct teaching into the lesson where I think a student would otherwise make the discovery on his/her own. I point out that most of the land of the model, including Banana Valley and Maple Leaf Valley, are contained within this large valley, all within a great, continuous series of ridges and peaks which encompass the valley in a great U shape.

“So you can have a baby valley inside a bigger valley?” asks Dalia.

Over the years of my teaching children and adults, I’ve come to prize student initiative, student questions, comments, student observations, comparisons, hypotheses…whatever is generated by the students, unbidden. I make a point of praising such comments, even if the student didn’t raise his/her hand. I want to encourage that kind of active engagement, which does not respond to a teacher’s question or search for what a teacher wants.

“That’s a very nice way to put it,” I respond to the student’s question. I see an opportunity to follow up with that student, to engage her further on the point about valleys within valleys. “Do you consider Death Valley to be part of Valle Grande?” Asking a student’s opinion in front of the group, makes the point that questions do not necessarily have “right” or “wrong” answers as determined by a teacher or a text book, that the answer may be a matter of opinion, and that the student’s opinion is important. Moreover, it is a mark of respect to have someone, a teacher no less, seek your opinion. A teacher who seeks the opinion or her/his students must certainly gain respect in their eyes.

Dalia considers a moment and says “no.”
“Why not?”

“Death Valley is not inside the big ridge ring.”

“Use the stick to point as you explain.”

“It’s outside the ring, here.” She points, and no one seems to disagree.

“Let’s say the names of the various valleys together as I point to them. And remember to say ‘Valley’ after each name.” I point to the valleys and the students, in surprising unison, name each one.

“Maple Leaf Valley, Banana Valley, Death Valley, Valle Grande.” I am constantly, almost subconsciously, assessing the group, especially to see whether they are engaged, enjoying the learning, whether I am lowering their inhibitions, encouraging their participation, curiosity, initiative, their risk taking, lowering their fear of “getting it wrong.” I am satisfied that this group is pulling together around the lesson and it’s time to move forward.
I place a wooden centimeter cube (any small marker will do) in Maple Leaf Valley and another in Banana Valley. “This is Ramon’s house,” I say, pointing to a cube near the entrance of Maple Leaf Valley, “and this house belongs to Amanda,” I say, pointing to the other cube, near Amanda, high up in Banana Valley. “Amanda, pretend you are traveling on horseback. You want to ride from your house to visit Ramon.” There are some teasing “ooohs” as though this meant romance, but it settles.

“You’ll need to find the gentlest route through the mountain ridge which separates Banana Valley from Maple Leaf Valley. Gentle slopes, Amanda, move us along with the stick. And tell us about the landforms as you move across them.” Amanda finds a gentle way up to the ridge that separates the valleys, but she hesitates on the ridge.

Ramon speaks up and says, “Go here,” he says, “It’s easier.” Ramon is pointing to a lower part of the ridge.

“Feel it with your finger, Amanda, and see if it’s sharp like the rest of the ridge, or rounded,” I suggest.

“It feels smooth.”

“More round or more sharp.”

“More round.”
“Then Ramon’s suggestion is good. This is a safe passage through the mountains.” Amanda moves her stick over the lower, rounded part of the ridge and then down a long, gentle slope toward Ramon’s house. “Look at the chart, they call this “safe passage” through the mountains a pass. It’s the fifth one on the chart, right after ridge.”

“The chart says gap too,” says Kamal.

“It’s a space between things,” I say. “What things is the gap between?”

“It’s between the mountains.”

“Show us,” I say. Amanda points with the stick to show us.

“My little sister has a gap between her two front teeth,” Another student says laughing. “And she squirts water at me through them.” There is more laughter. I don’t think anyone will forget Amanda’s journey to Ramon through the pass, or Lisa’s little sister with the gap-tooth. Some geographic structures are significant because of some human activity. I look for opportunities to role play human activities on the model, particularly where they will help to illustrate an activity associated with that landform. Passes hold great significance for social studies students. White settlers moved through passes in the Appalachian Mts., to find land in the Ohio Valley. White settlers moved through passes in the Rockies to get to California. Native Americans tried to head off the white invasion of their lands, sometimes by “heading them off at the pass.” Without some reference to three-dimensional materials, like a terrain model, what student could actually picture, from a map, what a pass was like?

Next, I have another student take us on a walk along the entire U shaped ridge, over as many mountain peaks as she can, verbalizing as she goes. Mountain climbers often walk ridges to ascend mountains or to go from peak to peak, and so this little role play will prove useful. “I’ll go up this gentle slope, then onto this ridge, then along this ridge to this peak.”

“OK, stop and take a selfie, and let Edward continue the ridge walk,” I say, trying to give more kids a chance to participate. Edward moves the stick along the ridge, until he’s walking on snow.
“Be careful, Edward, this ridge is dangerous. What happens if you slip?”

“You go down,” says Edward in mock fear. As in literature, role play, in this case a ridge walk, requires the “suspension of disbelief.” Children in the 4th – 6th grades have not lost the willingness to pretend, to imagine themselves up there on the ridge.

“Where? Show us with the stick.”

“Well, you could go this way,” he says, moving the stick sharply down one slope. “Or you could go the other way.” Again he moves the stick sharply down, only this time on the other slope. Although the prospect of plunging to one’s death is grim, there is much laughter as Edward moves his stick down one side or the other with a look of mock horror on his face. He has made a comedy out of this perilous drama.

“Looks bad either way, Edward. So try not to slip. But why are there only two ways to go down from the ridge.” Daphne offers that there are two slopes leading down on either side of the ridge. I ask if that’s true of all ridges, that they have only two slopes? I suggest they each turn and talk with their neighbor about this. There is a lot of pointing and talking about different ridges, and several students offer examples where ridges branch off and the number of slopes becomes complicated. Overall, the class agrees that most ridges have two slopes, and that where the slopes meet, there is the ridge. This generalization came from experience with the model, from an imaginary ridge walk, from student observation and student discussion. The students seem to be getting comfortable with this kind of learning, as long as the activities are fun and they can imagine themselves traveling on horseback or walking on a high snowy ridge in the mountains.

The ridge-walk continues all around the horseshoe shape of the mountains. Several students participate, pointing out the peaks, ridges, and passes as they go, taking care not to plunge down the slopes with a careless step.

“You have a series of mountains here, connected by ridges, and sometimes passes,” I say when the journey is complete. “Look at the chart; it’s the next term after pass and gap.”
“Mountain Range!” Several students call out, reading the term off the chart.

“I call it the Horseshoe Range,” I say. “Now think of your ridge-walking trip. There was a long series of peaks connected by…”

“Ridges.”

“And sometimes… (think of Amanda’s passage through the mountains…”)

“Passes, gaps.”

“So put it together: A mountain range is a series of mountain peaks connected by…” I say.

“Ridges and passes!” several students respond.

“Ok, would someone like to give the whole definition of mountain range?”

“It’s a bunch of mountains connected by ridges and passes.”

“Don’t start with a pronoun, start with, ‘A mountain range is…”’ Various others gave their own version of a definition for mountain range. Again, these were not definitions students looked up in the glossary of their text book and memorized for a test. These were definitions that the students composed from their own observed experiences with the terrain model. We work on each of the remaining terms on the chart in the same way as we worked with the earlier terms, with me
pointing to one example and naming it, and then passing the stick so students can find their own examples.

“These canyons look all connected,” observes a student after many canyons have been identified.

“Good observation,” I respond.

“Is there water in the canyons?” asks another student.

“Do you see any water?” I ask. Another student starts pointing out where she thinks the water would be if this was a real canyon. I point out that next class we would pour water on the model to see if it ran through the canyons. When students begin pointing out plains, another objects.

“Is this a canyon?” asks another student, “or is it part of Death Valley.”

“That depends on what the map says.” I explain. “If the map maker calls it Skeleton Canyon, then it’s a canyon. If the map maker doesn’t name that place a canyon, it’s probably just part of Death Valley.”

“Why does the map maker have so much power?” one student asks.

“Names are made by humans,” I suggest.

“It is what it is,” someone adds philosophically, “It’s the same thing, no matter what you call it.” That thought seems to hover in the air as people think about it. We move on to the term plains. I point to one.

“We already called that a mesa, how can it be a plain.” They look to me for an answer. I answer the question with a question.

“Is this part of a valley?” I say, pointing to Banana Valley. “Or is it a slope?”

“It’s both,” someone says.

“Can’t this be a mesa with a plain on top?” I ask another question. Those questions seem to make a point and students go on to point out many plains. Plateau gives us problems, because a plateau is so large, so conceptual, it is difficult to depict it on a model. I explain that a plateau is higher up than the land
nearby, but that it is not flat, necessarily. There could be a mountain range on a plateau. I try to point out where the plateau would be on the model. There are more questions, discussion.

When the terms have been completed, we work on “higher than…” and “lower than…” statements.

I point to a mountain peak and say, “this peak is higher than….” Here I point to a plain. “…higher than this plain.” I tell the students that they can choose any landform to compare to any other landform, but they have to name the geographic landforms and use the words “greater than” or “less than.” I write the statement on the board, underlining and calling their attention to the spelling of than. This is the word for comparing things. “This peak is higher than that valley.” I also write “This valley is lower than that peak.”

The students begin their statements:

“This peak is higher than that peak.”

“This ridge is higher than that plain.”

“This valley is higher than this mountain peak.” The floor of the valley is high among the tallest peaks on the model. The mountain peak is one of the snowless ones rising from the floor of Death Valley. How can a valley, which is low, be higher than a mountain peak? On a terrain model, this seeming contradiction is comprehensible for all. The terrain model serves as a concrete embodiment for the abstract concept of relative elevation. On a flat map, this comparison would be difficult, if not impossible, for elementary school students to comprehend.

It is intriguing to the students that the bottom of a valley should be higher than the summit of a mountain. There are comments, one to another, but words cannot express the conundrum of how a low thing like a valley bottom can be higher than a high thing like a mountain peak.

“Some things are higher than others, even when you don’t think of it that way,” explains one student with a shrug. Although students seem to appreciate concrete examples of relative elevation, explaining an abstract concept in words is
beyond their still concrete language. The “higher than and lower than statements” continue, with some ordinary comparisons, and with some unexpected ones:

“This pass is lower than the rest of the ridge.”

“This plateau is the same height as this plain.”

“This butte’s top is lower than the plateau.”

“This mountain peak is lower than nothing,” says Franny. Some students object, but Franny explains that her peak is the highest peak, and that’s why it’s lower than nothing.

“Could you make a ‘higher than’ statement about this same peak? I ask.

“This peak is higher than everything else.” Higher than everything, lower than nothing. This makes the point, very concretely, that there is more than one way to say the same thing. This kind of language play is so important for developing children’s flexibility in verbal and written expression. The students seem to enjoy choosing their own places to compare. They are listening to one another and getting ideas from one another about interesting comparisons, new and inventive kinds of comparisons. They are applying the terrain landforms as they do the activity and reviewing the meaning of each term. They are practicing, as well, using the terms in sentences. Without realizing it, they are gaining a deep understanding of relative elevation as they make their statements and listen to the statements of others. This relative elevation will be crucial for the next lesson with the terrain model, when we pour water on the model to form rivers. It is time for the group to reflect on their experiences with the terrain model.

“So let’s pause and talk about this landform lesson. How were you learning in your terrain landforms?” I posed the question as concretely as possible.

“You taught us with the model.”

“You had a list of words, but we had to kind of figure it out for ourselves.”

“You point first, and then we find other ones of the same thing.”

“You brought the model, which was fun. So you did something.”
“You gave hints when we were stuck.”

“You have to watch what other students are doing, and that helps you figure out what to do.”

“You told us about the buttes.”

“You wouldn’t tell us the answer about flat top mountains. You made us discuss it, and then you told us.”

“We didn’t have to take notes.”

“I like this way of learning with a model. You can see everything for yourself.”

“We helped each other. That way you don’t get it wrong.”

“You can pass and not lose your turn. That’s a good idea. Let’s say you didn’t know the answer at first, but later after you watched other kids, you figure it out. You get your turn back and you can get it right.”

The student to my left adds, “The hardest thing is when you sit next in line to the teacher, and so there’s only one example to go from, and no one else has pointed, and so you don’t get any help from your peers.” (This is a good reason to start the pointing from different parts of the circle).

In more formal pedagogical terms, this was knowledge that was “constructed” with the aid of peers. It was knowledge that was “discovered” rather than received. It was “student-centered learning” not teacher-centered. One could use the terrain model for direct instruction, where students took notes and learned definitions that the teacher illustrated with the terrain model. I am making the point that I am writing here not only about a material (the terrain model) but about a progressive teaching method, a method built on an understanding children’s cognitive and affective development, a method which creates curriculum appropriate to that level of development.

It is important for students to see what terrain really looks like, particularly after working with a terrain model. A slide show is easily created with the aid of Google Images and a format like Power Point. A smart board is necessary to
project the slides, but if none is available, there is no shortage of pictures of
mountainous terrain for teachers to find in books or to cut out of magazines and
hold up for students to see. Captions are best left off to enable students to interact
with the images. I’ll present a few slides of terrain and some of the discussion that
might go with them. Suffice it to say, this is a wonderful way to see your students
apply what they have learned on the terrain model to real images of terrain.

Students have many questions about this image: where is it? Who took it? I
tell them it is the Annapurna Range, part of the Himalayan Mountain Range in
Nepal. I am confident that my use of the word range will be understood. I ask
students to approach the slide with the pointer and identify peaks, ridges, and
slopes, just as we did with the terrain model. I ask a student to walk the ridge,
pointing out the steepest parts of the ridge.
In this slide, students see a Swiss Valley. They notice that the mountains are not snow covered, that the rock sticks out in many places, that forest covers many mountain slopes, but that the bottom of the valley is grassy. I give them the term Alpine meadow. We talk about the trail that goes through the Alpine meadow. They point out steep and gentle slopes and marvel at the clouds on the left that are lower than the mountain tops.

In this picture, an unpaved switch-back road zig-zags up a steep slope in South Africa until it reaches the top of the pass. Then the trail will descend on the other side.
In this picture from the American southwest, students can easily pick out buttes that rise from the desert floor. In the distance they can see the dark line of a mesa. The first slide, from Nepal, was my own picture, but the other two were easily found by searching for “images of mountain valleys” and “images of buttes and mesas.”

I know that individual comprehension varies significantly, in breadth and depth among a group of students. One student grasps all landform concepts quickly and easily, while others take longer. Also, particular students have trouble with certain landforms but not with others. Sometimes it is not until we see the Himalayan ridge in a slide that a particular child finally feels they “get it” about peaks, slopes, and ridges. I also know that individual assessment creates fear and tension in students. Individual assessment reminds students that the fun, the participation, the role plays, all boils down, ultimately, to taking a test, to judgement about how well they are doing. Individual assessment significantly inhibits participation, inhibits student initiative, inhibits curiosity, inhibits risk-taking, inhibits learning. There will be time to assess individual student learning much later when I can assure success for each student.
Meanwhile, there is a homework assignment which will help students reinforce and apply their learning in written form. I ask the students to take the landforms list and to make up a story which uses as many of the terrain landforms as possible. Then the next day they will read their stories to one another in small share groups.

“What kind of stories?”

“Well, you could do a horseback story like Amanda and Ramon.”

“What about walking Two Ways to Die Ridge?”

“I think you’ve got a title there, Edward.”

“Do you have to do one of those two?”

“No, do you have another idea.”

“Mountain climbing!” a student says, excitedly. We brainstorm a bit longer. I remind students to underline the landforms when they use them, and to include as many of the landforms, and their synonyms as they can. I also remind students that they will be reading their work in small groups so they should proofread and practice reading their stories aloud at home.

My hope is that students will be able to visualize as they write, to “see” the terrain on which they stage their stories. Some students have good comprehension of experiences but have difficulty expressing this understanding in written form. Other students may not have understood some of the landforms well, and others may have forgotten some of the terms. Nevertheless, I want them to take pleasure in what they’ve learned rather than feel badly about what they didn’t understand. Most of all, I didn’t want students to be distracted by who learned more, or whether they were smart as someone else, or smarter than everybody. This assignment was not a tool for comparing one student’s learning with another’s. This assignment was an extension of the in-class learning, a preparation for the writing share, an opportunity for students to deepen and to consolidate their understanding.
Conclusion: Part I

It was never my intention to write a guide-book for teaching with terrain models, or to create a set of comprehensive lesson plans. My intention was to write a narrative which would effectively describe how a teacher might get his/her students to deeply engage in exploration, in discovery of ideas, in constructing knowledge with their peers rather than receiving knowledge from their teacher. This short tract is about geography, but it could as well be written about math, or science, or about other subjects. Pedagogy is really my focus here. I wanted to show the role of the material, the terrain model, the role of the teacher, and the role of the students in this kind of learning. It is the dynamic nature of the interactions among teacher, students, and material which I wanted to describe, and it was this interest in pedagogy that required me to use dialogue to make my points.

The content of the river landforms and of the coastline landforms will be covered in summary, omitting dialogue, but including some of the important observations and discoveries that students make in these units. In the rivers section, we begin as before with a chart of landforms related to rivers.

Rivers

lake
river
source, headwaters
mouth
stem
branch, tributary
creek, brook, stream
river system

stem and branch river system
converge
diverge
divide, watershed
river valley
flood plain
confluence
estuary
This time we use blue-dyed water, a pouring beaker, and a watercolor pencil. We pour the blue-dyed water on the high ridges and let the water run down all the way to the mouth and out to the sea. Each time, I ask the students where we should make it rain, then they predict where the water will go, tracing it’s probable path with the pointer. Then we pour and observe the results. I draw the watercolor pencil over the path that the water took to record, graphically, the path of the river. We discuss the terms along the way, as we did with the terrain landforms. On the first pour, the high valley fills with water and forms a lake before overflowing to form the main river stem. I put a tiny bead of Styrofoam on the surface of the lake and pour more water. Eventually the lake overflow carries the styrofoam “boat” rushing down the river’s stem to the mouth of the river.

In this picture, I have poured water on every ridge and have drawn in not only the stem, from its lake headwaters, but each tributary leading from the ridges down to the stem and out the mouth into the ocean. The stem and branch river system is the overall organizing principle here and the students build it up, branch by branch. We count some thirty headwaters/sources which lead to the thirty branches, which converge to form larger branches, which eventually join the stem at “confluences.”

We experiment with a magnetic compass, examining which way the rivers flow. We pour darker dye into the lake and predict what will happen when the darker water (representing fresh water) flows into the lighter colored ocean water (salt water). We pour a larger volume of “rain” into the lake to see water overrun its banks onto the flood plain, and we experiment with sand, watching what washes downstream in a flood. We pour dye into a headwaters of a river and pretend it is a site of industrial pollution; then we try to predict which parts of the river will become polluted and which parts will be safe from pollution.
As we perform these “concrete operations” involving terrain, water, gravity, and earth magnetism, students are able to make many important generalizations. These generalizations are their own discoveries, the product of their own predictions and observations, with the teacher facilitating the activities, guiding the discussions. Among the generalizations and discoveries of the students are:

- Rivers run from high to low, from source to mouth.
- Rivers run in all compass directions, depending on the terrain.
- Ridges form divides for rivers to run down on opposite slopes.
- River systems have multiple sources and branches, but only one mouth.
- Smaller creeks, streams, and brooks converge as they go downhill, forming larger branches which join the stem at confluences.
- Branches typically do not split and diverge as they run toward stems; they converge.
- Tributaries and branches give their water to stems, never the reverse.
- Water runs downstream because of gravity.
- When fresh water meets salt water, you can see a plume of fresh water.
- When the tide mixes fresh and salt water, you get brackish water.
- An estuary is wherever fresh and saltwater meet.
- Fresh water and salt water usually meet and form brackish water at the mouth of a river.
- When there is more than usual rain, rivers can overflow their banks onto flood plains.
- When floodwaters recede from flood plains, sand and other debris is often left as residue.

It is worth noting here that, if the struggling student Egyptologists of the introductory anecdote had discovered some basic principles of river behavior through work with a terrain model, e.g., that rivers flow from high to low, ignoring compass direction, or that seasonal floods leave deposits on flood plains when the floods recede, they might have ultimately deduced something about the gift which the Nile brings to Egypt.
With rivers, as with terrain, a slide show is important to link the experience of the terrain model with images from nature. The rivers may be directly related to your social studies unit, or they may be more generic. The following three images are from Google Images.
Although this a map, not a photograph, it is such a wonderful display of stem and branch river systems that I cannot resist presenting it to students.
Coastline

This is the third and final group of landform terms I cover in this basic 4th – 6th grade curriculum, and I will cover the content of this curriculum in the same fashion as the rivers unit, summarizing our activities broadly and then listing some of the important discoveries the students make.

<table>
<thead>
<tr>
<th>island</th>
<th>inlet, strait, channel</th>
<th>sea level</th>
</tr>
</thead>
<tbody>
<tr>
<td>peninsula</td>
<td>shoals</td>
<td>estuary</td>
</tr>
<tr>
<td>isthmus, neck</td>
<td>ocean, sea</td>
<td>barrier islands</td>
</tr>
<tr>
<td>cape</td>
<td>archipelago</td>
<td></td>
</tr>
<tr>
<td>gulf, bay, sound, sea</td>
<td>coastline</td>
<td></td>
</tr>
</tbody>
</table>
As with terrain and rivers, we begin by pronouncing the coastline landforms first. I set the flooding in the context of a climate change that causes sea level rise. Students are asked to predict where the terrain will flood first, and why. As more water is poured, peninsulas form, and Death Valley fills with water, becoming a bay. The rising water narrows parts of the peninsulas into necks, and eventually those necks are submerged, forming islands.

Now there are shallow straits between the islands where the necks had been, and the necks, now submerged, form dangerous shoals in the straits. The shoals are light in color, but one strait is dark. It is the deepest and therefore the safest strait for mariners, the best inlet to the bay. The mouth of the river has moved, and the river system empties into the bay. We pour the darker water into the lake and let it flow downstream, as before. Now the plume flows from the new river mouth into the bay. At first the brackish water is limited to the freshwater plume by the mouth of the river, but when we rock the tray, tides wash saltwater upstream and spread the plume more broadly in the bay. Now the lower stem of the river is estuarial, as is most of the bay.

We launch small styrofoam boats in the lake upstream and watch them flow down into the bay. Then we rock the tray slightly and see how the movement of tides moves the boats around. We observe how the boats seem to fly through the inlets and swirl around in the bay. We speculate about causes of swift water in the inlets. We compare the speed of the water’s movement through the deep strait and the shallow ones. We note how far upriver the salt water pushes at high tide.

I focus students on the issues of sailors in and around shallow bays and barrier islands because we will be doing a social studies unit on the failed 16th century English attempt to found a colony on Roanoke Island. The island colony sat in Pamlico Sound, protected by the Outer Banks, an archipelago of barrier
islands protecting the bay from the ocean winds and waves. I created this model to include barrier islands and an island in the bay to support the Roanoke curriculum.

We discuss “running aground,” and we try to find the safest inlet into the bay. We pronounce and discuss the sentence, “Be careful not to run aground on the shoals!” We discuss the nature of barrier islands and the advantages and disadvantages of living on the island in the middle of the bay, protected by the barrier islands from wind and waves, but also surrounded by dangerous shoals that might make it difficult to ship in supplies from outside the bay. We discuss how waves tend to break over shoals, and how breaking waves could warn sailors away from dangerous shoals. We discuss night navigation, and students discuss where to place lighthouses to guide sailors through the deeper inlets. We discuss fishing opportunities that shoals afford, including nets, and spears, fishing weirs, and raking shellfish, all techniques of the Algonquian Indians in the Outer Banks at that time.

As with terrain terms, and with river terms, students are able to make generalizations about coastline landforms, discoveries made through their own experiences and observations of a terrain model. Among the discoveries and generalizations that classes make about coastline landforms are:

- The lowest elevation areas flood first when sea level rises.
- Mouths of rivers tend to flood first because they are naturally the lowest elevations.
- Cities located at the mouths of rivers are especially vulnerable to sea level rise.
- As the tide goes in (floods), salt water pushes into the river mouth and into the lower stem of the river.
- Cities at the mouths of rivers can’t drink the river water because it will be brackish.
- Light colored water is shallower, and dark colored water is deeper.
- Tide moves more swiftly in narrow, shallow inlets, more slowly in wider, deeper inlets.
- Shoals are dangerous for ships and boats, both for the danger of running aground and because of the swift running water and breaking waves.
Most adults’ geographic learning came through flat maps, through memorized definitions of landforms, and through memorization of capitals of countries or of the fifty United States of America. Because adults’ geographic understanding was stunted in this manner, some basic concepts are missing and consequently reveal themselves to children and adults in much the same fashion. Some dialogue here will illustrate. The student voices could be those of children or adults:

“So then is everything connected?” asks a student.

“Connected how? What do you mean?” I ask.

“Well, like the islands. They look separate, and you can sail boats in between them. But aren’t they really connected?”

“Where are they connected?”

“You know, like under the water.”

“Connected by land?”

“Yes, like when we started out, there was no water, and everything was connected. There were no islands.”

“So if we drained off the water, we’d see everything connected by land again?”

“Yes, can we do it?” The plastic model is so light that I can easily lift it out of the water and set it next to the tray on the floor. We are reminded of how we started out with mountains and valleys, and how Death Valley was dry land, whereas now it was the bottom of a great bay. The concept that dawns on students, adults and children, is the continuity of the earth, above and below the sea. Students who had been made to learn the capitals of the fifty United States when they were in grade school, and who had forgotten most of them by now, had no inkling in their geography education about this most basic concept of how water and earth relate to one another on a planet with its own strong gravity. Nor is this the only concept which the terrain model reveals to students young and old, concepts so basic that it seems impossible that students did not know.

Lucy Sprague Mitchell, founder of the Bank Street school and college of education in New York City, wrote in her 1934 book, Young Geographers, of taking her students out on a field trip to see islands in the bay. Her students believed that the islands floated on the surface of the sea. Mitchell, aghast, asked her students to draw a “fish-eye view” of these islands. One student drew an island moored to the bottom of the sea by a strong chain, much like a ship is moored to its
anchor. Mitchell makes the point in her book about geography education that we cannot assume that students have an understanding of concepts of which they have no experience. It is no wonder that students who have never worked with a terrain model, and whose geography education was limited to feats of memorization, should have the same sorts of revelations as do children regarding the continuity of land beneath the sea, or the behavior of rivers.

**Slide show of coastline terms**

Eventually we see a slide show of the Outer Banks, including Roanoke Island, Pamlico Sound, and the barrier islands of the Outer Banks. The English ship *Tiger*, loaded with English colonists, ran aground on shoals in 1585 as it tried to get through the barrier islands to Roanoke Island.

![Slide show of coastline terms](image)

The grounding of the *Tiger* opened her seams and allowed salt water to enter, ruining the food supply of the would-be English colonists. With their food supply ruined, the English were dependent on the local Algonquian Indians for food. When this food dependency became onerous for their Algonquian hosts, it led to violence: ambushes, a beheading of an Algonquian king, kidnapping for food, all of which led to the demise of the colony. If the Tiger had not run aground on the shoals in Ocracoke Inlet, the colony might have survived on its own food.
supply, and the first Roanoke Colony may not have failed. How could my class ever understand the history of the Lost Colony of Roanoke without an understanding of the physical geography of barrier islands, inlets and shoals? And how could a class ever understand this geography without a terrain model?

Through their work with the terrain model, students have gained a good understanding of the geography and nomenclature associated with terrain, rivers, and coastlines. In many cases they have gone beyond pure physical geography and discussed the human geography of particular places. In the terrain section, they came to understand the significance of passes, so important for a curriculum which deals with migration through mountainous regions. In the rivers section, they came to understand the opportunities and dangers of farming on a flood plain. In the coastline section, they learned about some of the navigational issues present in
shallow bays with their shoals and tricky inlets. These students now have the fundamental understanding necessary to make map symbols meaningful. What is needed here is a flat map of the three-dimensional terrain model with which they have been working, a flat map which would express the same three-dimensional phenomena in two dimensional maps.

**The transition from terrain model to maps**

In order to have the most meaningful transitions from concrete objects and experiences to abstract symbols, the model and the map can be juxtaposed. The map below was created to show every feature of terrain model, rivers, elevation, and coastline, from a bird’s eye perspective. This juxtaposition of model and map can only reinforce the relationship of objects and symbols for the students. Later, the terrain model can be removed, and students should be able to reason with the symbols themselves, remembering the shapes and relationships of the physical terrain model through the symbolic language of the map.

Eventually, students should be able to look at maps of places they’ve never seen and be able to visualize, from the standard graphic symbols, narrow ridges, gentle slopes, vast river systems, shallow inlets, treacherous capes. Beyond that, grounded in experiences with concrete materials, students should be able to make important inferences from looking at flat maps. For example, they should be able
to infer from a map of Africa that the Nile flows from several branches in the south, northward, out the mouth, into the Mediterranean Sea, that the flooding along the Nile could bring much needed fresh water to farms on the flood plains, answering the “Gift of the Nile” question. They might also infer that ancient Egyptians would need to figure out ways to hold onto some of that annual flood water for irrigating crops since there is no rainfall in Egypt.

**Introducing students to the map of the model**

I give out copies of this map of the terrain models to partners as we sit in the ring, looking down on the terrain model which they have come to know so well. I show students how to orient their maps so that they match the orientation of the model. Then I tell the students to look with their partners for correspondences between the model and the map. If I have more pointers, I would let the partners have them, or they can just point to the model.

Students are invariably amazed and delighted by the map, its colors, and the correspondences between map and model that leap out at them. I tell them to take their time and “explore” the map, that after a bit, partners will share with the group some of the correspondences they have found. Partners are quickly
engaged with in pointing out to one another places on the model and locating them on the map. I can hear the specific names of places said aloud. Whether elementary students, middle schoolers, or adults, Nepalis or New Yorkers, they see peninsulas and peaks, rivers and ridges on the map and match them to features on the discover islands and inlets, model. “Here’s Manahatta Island (the Lenape name for Manhattan Island, on which PS 59 is located!)

These 7th graders in the Kamane School in Hetauda, Nepal were as excited as the 4th and 5th graders from York City to be exploring a map of the terrain model they had worked with for three days. These students had limited English, but for this activity they could converse freely with each other in Nepali once the initial instruction was given to match features on the model with symbols on the map.
Teachers in my workshop at the Rato Bangala School in Kathmandu, Nepal, reacted with enthusiasm equal to their younger counterparts at the Kamane School and in New York City. They needed no focusing from me after the initial instruction to find correspondences between features on the model and symbols on the map. Nepal itself is landlocked, and many have never seen the ocean let alone the coast. Moreover, it was difficult to find Nepali words for some coastal landforms. Two teacher trainers from Rato Bangala scratched their heads over a word for strait/channel/inlet. Eventually we invented a landform, in Nepali, *pani jane galli*, which means “water alley.”
The spontaneity of the learning when students first get their maps, the freedom of exploration, the excitement of discovery completely absorbs the students. It amuses me that a teacher’s typical preoccupation with students’ being “on task” is not even a remote concern here. Whether with adults or with kids, in Nepal or NYC, I am free to observe, to walk around with my camera and photograph the students. After perhaps ten minutes of free exploration, I ask pairs to share something they found with the group. I ask them to use the alpha-numerical (letter and number) coordinates to direct their classmates to the geographic feature they are sharing. Here is some dialogue from the New York City fourth graders at PS59 as they shared some of what they’d found:

“There’s the big horeshoe ridge called Ashokan Mountain Range 1D.”

“There’s the pass through the mountains Amanda took to Ramon, 3F.”

“This is Corn Valley, 5E,” one team said, and then added, “and there is plenty of corn there too!”

“There are beavers by Mohawk Lake.” These New York kids studying New Amsterdam had maps with names and symbols appropriate for their New Amsterdam study. Without being told, students had begun to use the symbol key to identify the prevalence of corn in Corn Valley and of beaver by Mohawk Lake.
“I see Fool’s Inlet at B10,” a student offers.

“What an interesting name,” I comment, “Why do you suppose they call it that?”

The team consults and one student says, “There are shoals in the inlet, and it would not be smart to go into the bay that way.”

“Why wouldn’t it be smart?” I ask.

“You could run aground on the shoals.”

“How can you tell there are shoals?” I follow up again.

“The water’s color is so light.”

“Why would a ship want to get into the bay?”

“You have to go through the Great Barrier Archipelago to get to the Dutch colony, 9-10E.” (These students had also spontaneously used the key to understand the symbol for Dutch colony.) “The colony is in the bay, on Manahatta Island, and you have to find a way in from the ocean.”
“Can another team find a safe way into Manahatta Bay?” I ask. There is some discussion between team members, and then hands go up. I call one team.

“There is dark water at Welcome Inlet, 11C. You won’t run aground there.”

I decide to introduce the students to the index, elevation scale, compass rose, and scale of miles, all to prepare for some extended problem solving activity with the model and map.

I ask the students to recite the color sequence of the elevation key from top to bottom.

“Oh white, brown, orange, yellow, green, blue.”

“Which is higher, orange or yellow?”

“Orange,” they respond.
“OK, which color sequence will a river follow?

“White, brown, orange, yellow, green, and blue.”

“Why is this the color sequence for rivers to flow in?”

“Because rivers run from high to low.”

We review the key for Native American Villages. We look at the Index and note that it is arranged alphabetically. I write three Native American village names, Cayhuga, Seneca, and Mahican on the board.

“Use your index to find these towns. Then use your elevation key to list them in order of elevation, from high to low.” Our earlier “higher than and lower than statements” laid a basis for this increasingly abstract reading of a flat map.
The students order the towns and all the teams seem to agree that Mahican, orange in color, is highest up near Lake Mohawk, that Cayuga, yellow (yellow) is at the entrance to Corn Valley, and that Seneca (green) is low down and near the coast.

I ask the students to find Mt. Ashokan in the index. Then I write on the board the following directions involving the compass rose on the map.

I ask teams to find:

1. a mountain northeast of Mt. Ashokan
2. a mountain northwest of Mt. Ashokan
3. a Native American town southeast of Mt. Ashokan
4. a Native American town southwest of Mt. Ashokan
I direct students’ attention to the scale of miles and show them how to measure off 10 miles with their thumb on a pencil. Then teams should figure how far it is from Mahican to Oneida, using the index to find Oneida.

I tried hard to keep the introduction of map skills student-centered. I let the students explore initially. As much as possible, I tried to embed the work with index, key, elevation, scale of miles, compass rose within the context of problems for students to solve. I’ll have the students do a short journey problem in the time that remains of the class period. I think it is important for students to use a map as a problem-solving tool during this initial exposure. This allows them to see the map as a tool that accomplishes some purpose.

**Journey Problems**

A journey problem is a narrative, written in the second person, so that the readers feel that *they* are taking the journey. The story has an origin, a destination, and some obstacle to surmount. Throughout the journey problem there are numbered short answer questions; the answers are on the back so that students can self-check. A good journey problem requires the students to use each aspect of the map: index, key, elevation, scale of miles, and compass rose to answer the questions. This journey problem is not an assessment tool, it is a learning activity that should be enjoyable for students. The journey problem gives students an opportunity to apply their geographic concepts and map skills in a problem solving context. I construct these problems to be interesting, to require thinking, and to enable students to be successful. Here is a sample journey problem which teams could work on in their initial experience with maps.
Manahatta Island Journey Problem

You are sailing from Amsterdam to the New World. Your destination is the Dutch Colony on Manahatta Island (find it with your index). What is the safest inlet through the Great Barrier Archipelago (find it with your index) to reach the colony? 1. _____

You trade some pots and kettles with the Lenape Indians and get a canoe in return. You want to visit some Native American Villages where you can trade for beaver pelts. Paddle northwest from the Dutch colony to the mouth of a river. What River is it? 2.______

Paddle north on this river until you get to the second eastern confluence. How many miles from the mouth of the river to this confluence? 3.______ Were you paddling with or against the current as you traveled from the mouth to this first confluence? 4.______

Paddle up the Mohawk River (find it with your index) from this confluence. What direction are you paddling? 5._____ How many miles is it to your first Native American village? 6.______ This village has no beaver pelts to trade, but they tell you that there are plenty of beaver up in Beaver Creek. (Use your index to find this creek, but
remember, you are still back in Cayuga.) Leave your canoe in Cayuga and continue on foot. Follow the Mohawk River upstream, crossing on footbridges where you need to. When you get to Beaver Creek, there are no Lenape Indians to trade with. Climb northwest along the creek up to the pass. From the top of the pass, look down and to the northwest. What lake do you see? 7. _____ What Native American village do you see on the west side of the lake? 8. _____ Use your scale of miles to see how far away it is. 9. _____ You can walk three miles in an hour. How many hours would it take you to reach the village walking at this speed. 10. _____

Answers to Manahatta Island Journey Problem

1. Welcome Inlet. 6. 20 miles  
2. Hudson River 7. Mohawk  
3. 20 miles 8. Mahican  
4. against 9. 20 miles  
5. northeast 10. almost 7 hours.

Fifth graders from PS 59 solving a longer journey problem.
Students enjoy collaborating with their map partners over the journey problem. They love the answers on the back for self-checking. They enjoy flexing their newly found cartographic muscles, using the map as a tool to solve problems. They love the self-sufficiency they feel with the map. If the narrative is fashioned well, and if it relates to the social studies we are doing, they enjoy the content of the journey problem as well.

Additionally, students can ask one another questions to solve on the map. These could be spontaneous, or they could be written out by students beforehand. These two 7th grader map teams at the Kamane School finished their journey problems early. Now they are making up questions for one another to solve.
Here, Rato Bangala teachers try their hand at writing their own journey problems for their maps, journey problems that they fashion with the interests and needs of their own students in mind. I think the composing of journey problems was a very beneficial part of the learning process for the teachers, and I know it would yield great benefits for the students. Were teachers of a mind, they could make their own maps of the model. Perhaps, over time they would develop the confidence and interest in doing so.

**Assessment**

When teams feel confident, they can do a journey problem where they write the answers out and the teacher can check their work. Because students are able to decide when they are ready, and because they can work in pairs, it feels less to them like a test, but more like a challenge they are eager to undertake.

Likewise, when individual students feel ready, they can do a journey problem individually. Often students are eager to try their hand at solving a journey problem by themselves. They see “going solo” as a challenge they are ready to take on. By this point, having practiced having journey problems in pairs, individuals usually get every item correct, or at the most one or two wrong.
Students don’t “study” for these tests in the conventional. The learning was experiential, more a matter of doing than receiving and retaining. The journey problem is one they haven’t seen before, but they use the map they are familiar with, the map of the terrain model, to answer the questions. These journey problems serve as assessments of an individual student’s knowledge of geographical terms and concepts as well as their ability to use a map to solve problems. These tests require students to know and understand terms and concepts having to do with terrain, rivers, and coastline, and to know and understand how to use all the parts of a map, including index, key, compass rose, scale of elevation, and scale of distance. But these tests go beyond simple test of knowledge, they are tests of students’ ability to apply their geographic knowledge and map skills to problem solving.

### Using Real Maps

After working with the terrain model and the map of the model, students need to apply their concepts and skills to real maps. The Nepali students were introduced to the map of South Asia which focuses on the river systems which drain eastern India, Nepal, Bhutan, Tibet (southern China), and Bangladesh.
As complex as the map appears, it was easy for students to find the many sources, and then trace the converging branches of the Ganges and Brahmaputra River System, all the way to its mouth, the delta on the Bay of Bengal. It was a revelation to the students that all of their country’s rivers, including their own Rapti River were branches of the Ganges with its mouth on the Bay of Bengal. Students were further amazed to realize that the Tsangpo River flowed over a thousand miles east before plunging down some 10,000 feet and eventually to the same delta as the Ganges. After this map introduction to the river system of South Asia, they saw a slide show.

A note about the Brahmaputra River: It begins as the Yarlung Zangbo River, but it is also known as the Tsangpo River at that point. The slide show begins at the westernmost source of the Tsangpo River, high on the Tibetan Plateau in Tibet, China. The river descends some 10,000 feet at its eastern end, drops down to India, and changes its name to Brahmaputra. The last section of the river, where it flows through Bangladesh, is called the Jamana River. The Jamana joins the Ganges at the delta and flows to the Bay of Bengal. The slide show follows the course of this river. A few slides will convey the great opportunity a map presents to show the physical and human geography of a place.
The first 600 miles of the Brahmaputra is known as the Yarlung Zangbo. The river runs at over 4000 meters above sea level until it heads south into India.

900 miles from the westernmost source of the Yarlung Zangbo, is the city of Lhasa. The Dalai Lama used to rule Tibet from the Portola Palace, in Lhasa. In 1959, the Chinese took control of Tibet and the Dalai Lama fled to India.
On the plains of Assam, the Brahmaputra River begins to braid, winding through the sediments it is dropping.

When the monsoon rains come, the Brahmaputra floods over her banks and spreads over the flat land of the Assam flood plains.
After seeing the slide show of South Asian river systems, students are ready for a journey problem on the South Asian map. This journey problem will follow the course of the slide show along the length of the Tsangpo River. Many of the features of the slide show will be included in the journey problem. And of course students will have a teammate and their map with its index, key, compass rose, elevation scale, and scale of kilometers. Answers could be on the back, or teachers might let students fill out their twenty answers and then check for errors afterward. Here is a sample of the Brahmaputra journey problem:

**Brahmaputra journey problem:** You drop by parachute into Tibet, China to begin your journey. You will be traveling the entire length of the Brahmaputra River, from the river’s westernmost source to its mouth. You are dropped over Mt. Kailash somewhere near the Angsi Glacier (Use your index to see where you are landing.) You are carrying an inflatable raft and some supplies, including a compass. In what direction should you walk to find the source of the Brahmaputra? (Remember the Brahmaputra starts out as the Yarlung Zangbo, and also goes by the name Tsang po) 1. __________

When you reach the river, you inflate your raft and begin paddling east. Will you be traveling with the current or against it? 2. __________ How do you know? 3. _______ After you have traveled 450 kilometers, look south. What mountain do you see in the distance? 4. _______ How many kilometers away is it? 5. _______ Continue on the river 175 km further, and you’ll see the towers of the Protola Palace rising on the north bank of the river. What town have you reached? 6. _______ 175 kilometers further and you’ll have to get out and carry your raft for a bit. Why? 7. _______ In another 225 kilometers you’ll come to one of the most spectacular sights of your trip. What is it? 8. ____ As the Yarlung Zangbo turns south, you cross a dotted line on your map and enter what country? 9. _______ As you head south, you go from white, to brown, to orange, to yellow, to green in how many kilometers? 10. __________ How many meters of elevation have you dropped down? _______ 11. Was the slope more steep or more gentle? 12. _______ How do you know? 13. __________

This journey problem goes on through 21 questions, calling on these Nepali 7th graders to read and reason with the highly abstract and symbolic language of maps. Geographers say that map readers should be able to “read the world through
the map.” I hope that these young Nepali geography students could really see the great river Brahmaputra through their maps! I wonder how well they would see their South Asian region with the map alone, not having worked with a terrain model or its accompanying map, without a geography curriculum that encouraged them to think and problem solve, collaboratively, at every turn.

Conclusion

I’ve tried to show, in this extended manuscript, how geography and it’s special language, maps, are best taught. The entire approach rests upon the notion that students in elementary school need to learn with concrete materials and experiences before they are given maps to read. Sadly, in most U.S. elementary schools, geography is still taught through maps, maps which routinely confound students, maps which teachers find frustrating to teach their students to use. Neither students nor teacher ever realize that it is the lack of concrete materials, like a terrain model, that make geography so difficult to teach and maps so confusing for students to read.

As sad is the way geography has been reduced to memorizing bits of information: the seven continents, latitude and longitude, the capitals of the fifty United States, *the* source of a river. A true travesty is that the highest expression of geographic knowledge is embodied in geography bees where students compete to see who can hold the most information in their heads to retrieve at the right moment. And where has thinking gone? Apparently forgotten.

I have an idea for my own geography bee, where teams of students work to solve important problems with the aid of a particular set of maps. And there are so many important problems to solve, historical and present:

1. Name one city in each continent that is especially vulnerable to sea level rise. Use a world map.
2. Name one inland city, not on the coast, in each continent that is especially vulnerable to sea level rise.

3. Use your Hudson River map. If there was a chemical spill in Massachusetts on the Hoosic River, a branch of the Hudson, which NY cities and towns would need to be alerted to the danger?

4. If there were no American continents, where would Columbus have landed if he left the Canary Islands, his last port of call in Europe, and sailed west on the same latitude?

5. Use your early 18th century colonial map to list the colonies of the Dutch, English, Spanish, and the Portuguese. Write the present day city or country next to each colony.

This book is aimed at preservice and in-service teachers, particularly those students who have been in my graduate school classes, at City College of New York and at Bank Street College, or in my geography workshops for teachers. Nearly all of you were taught geography the old way, in elementary school, with flat maps, facts and memorization. It is my hope that you will take your terrain models and go into the schools that hire you, or the schools where you are already working, and that you will engage your students in this very satisfying and engaging project, geography and maps from terrain models.