AR Sandbox Curriculum

This four-part curriculum allows an instructor to show the capabilities of an AR sandbox to teach a group of learners (middle school students through undergraduate students) about topographic maps and how to read them.

Lesson 1: Topography and Bathymetry

Goal: Students will learn the terms *topography*, *bathymetry*, *contour line*, and *contour map*.
Time: 40 minutes

Engage (3 minutes): Use the following introduction to engage the class with the AR Sandbox. You'll need to start out with a simple mountain in the middle of the sandbox.

> *This is called an Augmented Reality Sandbox, or an AR sandbox… That's really just a fancy way of saying that it's a sandbox that gives you special information when you play around with it. See? Here's the image of what I've made here in this sandbox. It gets picked up by this sensor, processed by the computer, and then the projector shines it up there..*

Explore (15 minutes): Learners will work individually or in groups to explore the different aspects of the images generated by the AR Sandbox.

1. Have learners look at the topographic image of the mountain on the screen. On a piece of scrap paper they can sketch out and color a version of the map.
    a. What do the different colors mean?
    b. What are these lines about?
    c. Why are there big sections of blue?
2. Learners should come up with answers to these in their groups that can then be shared with the room.
3. Next, flatten out the mountain into a wide, flat shape. Ask the students to take another look at the map and see if any of their ideas change.
4. Ask for students to share out there ideas and write them on the board as an "idea bank."

Explain (5 minutes): After the room has had a chance to discuss their ideas, go over the following explanations of the earlier questions.

a. *What do the different colors mean?* This is an easy way to show how high things are. Red is very high and it gets lower after that through orange, yellow, and green.
b. *What are these lines about?* These lines show where things are at the same height. If you run a line around the mountain at the same height you'll create this line.
c. *Why are there big sections of blue?* At a certain height the computer puts in "sea level." Everything below this is underwater.

Elaborate (5 minutes): If you don't have the sand model in front of you, the markings on the image can tell you what the shape of the land is.

- The shape of the land is called *topography*.

- The shape of the sea floor is called *bathymetry*.
- The lines that mark the elevation are called *contour lines*. A map of contour lines is a *contour map*.

Evaluate (12 minutes): If sea level were to rise, how would that change the pictures above?

Lesson 2: Slope

Goals: Steep sections of a map have close together topographic lines, gentle sections have widely spaced topographic lines.
Time: 35 minutes

Engage (5 minutes): Make another mountain in the sandbox area for learners to examine. This is an opportunity to review what was learned last time and to get the group to think a little further. Ask the group *what can you tell from the shape of these lines?* In general, a curved hillside leads to curved contour lines, a straight hillside leads to straight lines, etc. What else can we tell?

Explore (20 minutes): In small trays, the learners can create different landforms and compare them to reality. Instruct the student groups to follow the steps below.

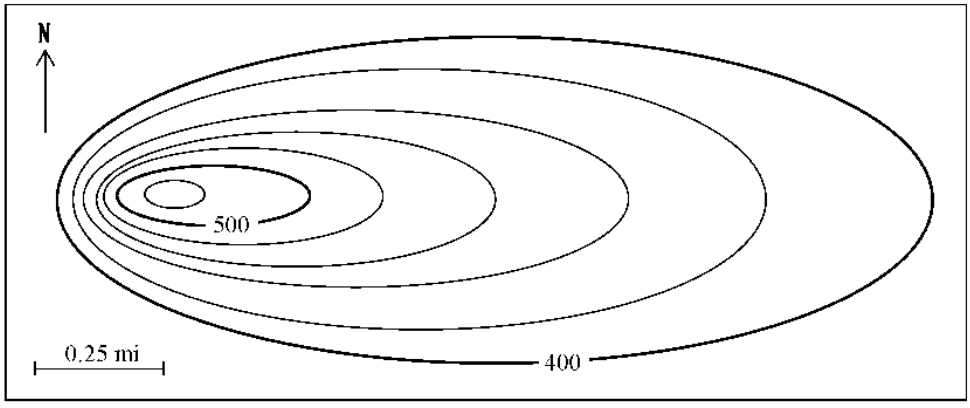
1. For each of the landforms below, students should create the landform in their trays.
    a. A hill that's steep on one side and gentle on the other.
    b. Two hills next to each other.
    c. A hill with a long valley running into it.
    d. Two *islands* separated by a stretch of water.
2. Once students have one of these landforms created, they should sketch what it would look like using the AR sandbox technology. Use colored pencils to recreate the color bands from the screen.
3. After groups have drawn their estimates of each of these landforms, the instructor can try it on the AR sandbox and check their work.

Explain (2 minutes): The colors are one expression of the height of the land but contour lines can show you how things look as well. Close together lines indicate a steep slope and far apart lines indicate a gentle slope. Even without the colors showing elevation you can see where the land is rising up and how quickly.

Elaborate (3 minutes): Ask the learners to think about the following questions.

- How could you use a map like this in real life?
- When would you want to use a contour map like this?
- What can you learn from this sort of map that you couldn't from a road map?

Evaluate (5 minutes): In the picture below, what part of the hill would be the best for sledding on for someone who wants to go fastest?



Lesson 3: Hilltops, Lakes, and Craters

Goals: Low spots and high spots on the map will be closed loops of topographic lines.
Time: 50 minutes

Engage (5 minutes): Ask the learners to think in their groups about when a contour line would end. What would that look like? The answer is that it's impossible. You'd have a line elevation that just… ends in space. So if they can't be a line that ends, then what are the rules?

Explore (25 minutes): Create the following shapes and see how it looks on the screen. Use these to come up with rules about the shape that contour lines can have.

- A steep mountain that comes to as tight a point as you can make. (Don't get too high, though, it messes up the Kinect sensor).
- A flat plain with a lake in the middle of it. (You need to get low enough that you're below "sea level").
- A tall volcano with a crater at the peak. (Make the crater deep enough that the color changes).

Explain (3 minutes): Contour lines have to be closed loops. On a topographic map they might "end" by going off the edge of the map, but if you had a big enough map you'd be able to see the full loop. The lines also can't cross since the point where they cross would have to exist at two different elevations simultaneously.

Elaborate (10 minutes): Turn off the projector and create a shape in the sandbox, a mountain or pair of peaks depending on how well the group has grasped the concepts so far. Have learners working in groups sketch what the topographic lines would look like. Once everyone has finished their sketches, turn the projector back on and compare the guesses to what the AR sandbox says.

Evaluate (7 minutes): Ask the learners to write a list of rules for reading topographic lines on the AR sandbox display. Collect them up and compare them to the following list of rules.

1. Contour lines depict areas of equal elevation. Elevations on one side are higher than elevations on the opposite side.

2. Contour lines spaced close together show a steep slope, or steep hills and ridges. Conversely, areas having contour lines spaced widely apart display a gentle slope.

3. Contour lines are continuous and will always close, even though they may run off the map before closing.

4. Contour lines will never split or intersect.

5. Contour lines that form circles on the map indicate a hilltop, or a place of higher elevation.

Lesson 4: Streams and Watersheds

Goals: Streams cause Vs in the topographic lines pointing upstream and tracing the enclosed topographic lines can show the watersheds in the map area.
Time: 60 minutes

Engage (8 minutes): Create another mountain in the AR sandbox. Review with students how the topographic image shows the shape of what you've created. Next, draw deep channels from the top of the mountain down to the base representing streams (should be 2-3 cm deep). How are the contour lines affected by the streams?

Explore (40 minutes): Learners will make their own streams with an aluminum pan, scrap paper, a plastic bag, and some blocks to prop up the pan. They'll also need a permanent marker, an index card, and a spray bottle of colored water. Ball up the paper and place them in the pan to make "hills," then put the plastic back over the top to make a surface that water will flow over. Put the blocks under one side to create an incline.

Using the permanent marker, learners will draw in the places where they think the streams will form. After drawing the streams in, use the permanent marker to trace contour lines of the land across the streams. The index card can be held up level with the tabletop to help with this process. To test things out, use the spray bottle to spray colored water over the top of the model. Do the streams form where the learners predicted?

Explain (5 minutes): When looking at the AR sandbox or the models on the table, you can see the area around the stream that feeds water into it. With the permanent marker, learners can place a dotted boundary to mark off the streams' watersheds based on the flow patterns of the drops of colored water. Note that the boundaries of the watershed are all the highest parts of the model.

Elaborate (5 minutes): Come up with some additional rules to add to the guidelines developed in Lesson 3. What is the rule for reading topographic lines that streams cross? How can you tell which direction a stream is flowing from the topographic lines? How can you anticipate the *watershed* from a topographic map?

Evaluate (2 minutes): Given the map below, ask learners to predict which direction the stream would flow and where its watershed is located.