Constructive Contours

Build a life-size topographic map on school grounds

"THAT'S NOT RIGHT!" PATRICIA SHOUTED. More slowly, but with confidence, she added, "Those lines can't cross each other. I understand why . . . I just can't figure out how to say it." Patricia had intuitively recognized that an important concept of topographic mapping was being violated. Her only problem was finding the words and self-confidence to bring it to the attention of others.

What Patricia was questioning was the placement of two contour lines constructed by classmates on the grassy slope outside our school. Given simple tools and limited instructions, students were constructing a topographic map of the school lawn *on* the lawn. In other words, they were making a full-scale topographic model they could see, walk through, and discuss.

WHY WE DEVELOPED THE ACTIVITY

Before we developed the Constructive Contours activity, our approach to teaching topographic map concepts relied on the traditional use of paper maps, small models, and discussions of important principles such as contour interval, contour spacing, the rules of V's, and so on. Standard assessment practices (multiple-choice questions and short essays) showed that our students could correctly remember or recite definitions. However, when we implemented some new problem-solving exercises that required students to apply map skills, we found that a substantial number of students had not developed a functional understanding of topographic maps. Consequently, the effectiveness of these activities was diminished by time spent on remedial teaching.

We also discovered that the traditional teaching approach did little to dispel students' misconceptions. One such problem was closure of contour lines (contour lines forming circles around hilltops, sinkholes, and so on). Some students firmly believed that every contour line should be a circle. Or, as one student put it, "The circles get larger as the land gets flatter." Because students were finding it hard to construct a useful three-dimensional mental image from a two-dimensional map (as suggested by Kastens, VanEsselstyn, and McClintock, 1996), we needed an activity that helped them see how a paper map can represent a three-dimensional object.

Our activity does this by letting students build a realistic model that clearly shows what a contour line is and why it behaves the way it does. The activity encourages intuitive judgment and gives students a foundation for correcting inappropriate ideas. It also provides students with a chance to improve their cooperative and collaborative communication skills.

THE TOOLS

The primary instrument needed for this activity is a plastic hand level (see photo opposite), which resembles a small telescope. Instead of seeing a magnified image through the eyepiece, the viewer sees a small bubble and a horizontal reference line superimposed in front of an unmagnified image. Alignment of the bubble, reference line, and object indicates the object is the same height above the ground as the viewer's eye. Plastic hand levels generally cost less than 15 dollars and are available from forestry supply companies. One hand level is required for each group of three students.

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Along with a graduated 2 meter stick (something students can make if time permits), a hand level can be used to measure the height or thickness of distant objects. By following a steplike measuring technique, students can use the measuring stick and hand level to measure changes in elevation. The accuracy of this procedure can be impressive. With practice, our students measure changes of 5 millimeters or less when using commercial folding rulers or surveying scales.

Field geologists use hand levels to measure local and regional changes in the elevation and thickness of rocks, especially along steep hillsides and road cuts. Thus, students have the opportunity to use the same tools and develop the same skills as professional scientists while learning a simple skill that may prove helpful later.

THE ACTIVITY

This two-day activity uses the sloping grassy areas on our school grounds. On the first day, students discover basic skills. Collaborative teams of three are formed. (More than three students per team seems to promote inattentiveness unless each student is assigned a specific role.) Each team is given a hand level and measuring stick. Everyone is shown the location of a previously placed artificial benchmark. (We estimate this elevation from the topographic map for our area.) We next point out the large *X* placed at the top of the slope. Our instructions are confined to a single statement: "What is the elevation of point *X* above sea level?"

Teams are then free to explore how the hand level, measuring stick, and benchmark can be used to accomplish the task. Some individuals quickly figure out how to use the hand level, but it normally takes teams longer to develop the steplike technique needed to actually measure the elevation. Students soon realize that correct calculations and good record keeping are important. Collaboration between teams is encouraged. By the end of the session, everyone is ready for the following day's challenge.

The next day we construct a topographic map of the slope. After clearly defining the work area, we explain that each team is responsible for constructing a contour line. Students are told to use a 0.5 meter contour interval. Smooth wooden or metal stakes are provided for marking points. Colored plastic tape strung on the ground between stakes serves as the actual contour line.

Students must discover how they can use the available equipment (hand level, measuring stick, stakes, tape, and benchmark) to construct their line. Experience gained from the previous day's work quickly bears fruit as teams begin to measure and mark points. Slowly, lines begin to emerge. As students proceed, they see the importance of making correct measurements and that more measurements (stakes) make a smoother line. They also begin to realize that every point on their line is the same elevation.

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HELPFUL IDEAS

The trick to this activity is developing the steplike technique required for measuring vertical change. For example, the procedure for using a hand level to determine the total height of a set of stairs is as follows:

1. Starting at the bottom step, hold the hand level along the side of your measuring stick.
2. Sight a level line to the next highest step you can easily see. (This will vary from person to person.)
3. Read and record the height from your stick. Move up to the step you just measured. Repeat this process until you reach the top.
4. Add all your measurements together.

In the field, on uneven terrain, the hand level is used in the same manner. It takes a while, but students eventually discover the process and how to use teammates' feet to mark newly elevated points.

The contour interval should be varied to make sure each team constructs at least one line. However, teams constructing lines far up the slope take much longer to complete their line than do groups working close to the benchmark. For this reason, we now ask some teams to make two lines.

One common problem that we have turned into a learning situation is that some teams suspend the tape from the stakes instead of stringing it along the ground. It is important for the students to figure out what is wrong with suspending the tape. Most students quickly realize that tape suspended in the air does not correlate with the measured ground elevations marked by their stakes—the tape is actually higher. In addition, the sagging of the suspended tape is not representative of the true path of the contour line.

We have also noticed that we must occasionally remind our students to make a contour *line*, not just locate a series of isolated points. Therefore, each team is required to use a minimum of five stakes. Additionally, we have found that having different classes construct maps in different areas stimulates "compare and contrast" discussions.

Some teams will decide to use a line constructed by another team as a reference. They may see this as an easy way to simplify the task. Fear not—frequently this leads to "good" problems, such as crossed lines. Students are then faced with the prospect of questioning peer work. We remind them that scientists constantly review and contest published conclusions. Uneven hillsides, flat playgrounds, and large obstacles (buildings and bushes) test student ingenuity. These situations often lead to "teachable moments" as students explore various possible paths for their line.

FIGURE 1.

Rubric scoring for Constructive Contours activity.

Topic	Scores			
	4	3	2	1
Collaborative Effort: Student takes charge of actions during a group activity.	Student willingly participates in team tasks, stays on task, volunteers for active roles within team, encourages sharing of ideas and opinions; cooperates freely with other teams.	Student needs encouragement to participate within team; stays on task, accepts role within the team, shares ideas with others, works well with other teams.	Student requires prompting to work with the group, must be reminded to stay on task, accepts team role, grudgingly shares ideas, unhappy to work with other teams.	Student is uninvolved with the efforts of the team, does not focus on the task, refuses to accept a role on the team, does not share ideas, will not work with other teams.
Skills and Processes: Student uses scientific skills and processes and intuitive reasoning ability to explore, discover, and construct a correct model.	Student explores different ways to use tools, demonstrates proper use of tools, accurate measuring important, makes frequent observations, records changes in model in notebook, demonstrates problem-solving.	Student explores limited ways to use equipment, demonstrates good use of tools, satisfied with good measurements, makes some observations, notes some change in model, tries to solve problems.	Student needs assistance in proper use of equipment, lacks accuracy in measurements, makes few observations, notes few changes in the model, does not demonstrate problem-solving skills.	Student does not try to use tools properly, does not measure consistently, does not make any observations, does not note any changes in the model, does not attempt to solve problems.
Content Analysis:: Student responds to discussion questions, reflective assignment, and intuitive learning.	Student relates position of marker flags and tape to changes in slope, compares model to actual land features, compares model and actual land features to a contour map, suggests model variation, communicates clearly and coherently.	Students relates position of marker flags and tape to changes in slope, compares model to actual land features, does not compare model and actual land features to a contour map, communicates in understandable manner.	Student has difficulty relating position of the marker flags and tape to changes in slope, has difficulty comparing model to actual land features and/or a contour map, poor attempt made to communicate.	Student does not relate position of the marker flags and tape to changes in slope, unwilling to compare model with actual land features or a contour map, will not respond to the discussion questions.

TEACHER'S ROLE

Our role in this activity is truly one of exasperated facilitator. Resisting the natural inclination to help struggling teams and individuals is difficult, and waiting for students to recognize blatant mistakes can be frustrating. We wait because when a student points out problems, the discovery has more impact on classmates, provides us additional insights into the student's cognitive processes, and significantly increases the student's self-confidence. However, we will intervene to redirect student discussion toward thoughtful evaluation and constructive resolution.

To ensure meaningful student progress, the teacher must allow sufficient time for experimentation and re-examination. After learning the basic skills the first day, our students can easily make a very good contour map of a 20 by 40 meter area during the next day's 45-minute class. Although the completed map may not be perfect, it does seem to provide the visualization tool many students need to actually understand contour maps.

DID THEY LEARN ANYTHING?

After completing the activity, students seem to have a much better understanding of what a contour line is, why the lines behave the way they do, and what a topographic map represents. Their ability to use topographic maps as a tool in later assignments demonstrates the educational value of this activity. However, to assess student progress in such an experiential learning environment, we needed to develop new evaluation procedures.

Our first assessment tool is a rubric (Figure 1) modeled after ideas presented by Ken Jensen (1995) and Julie Luft (1997). A posted copy of this rubric provides the teacher and students with a clear understanding of expectations. It also satisfies student demand for a clearly defined quantitative scoring procedure.

A more qualitative assessment is obtained through reflective writing. Because many of our students are not adept at this, we use our own directed-response journaling technique. We hand out a worksheet that helps students examine and question their thinking, experiences, interactions, and skill development by asking questions such as the following:

- Reflect on the experience you had—what did it mean to you?
- How did the team work together?
- Describe the model.
- How can a flat piece of paper show the irregular surface of the land?
- Which skills were most difficult for you to use?

Students use their own words to tell us what they have learned. This assessment tool also helps us identify erroneous ideas that need to be revisited and clarified.

Constructive Contours provides our students with the opportunity to build and explore a real, full-scale, three-dimensional model. It improves their understanding of topographic maps. Follow-up activities requiring map skills are more effective. Because it requires simple calculations, the activity engenders an appreciation of mathematics. It also encourages curiosity, stimulates a willingness to entertain new ideas, and makes students question their own and their colleagues' procedures.

The teamwork developed by this activity is one of its most enduring aspects. In a recent use of the activity with an eighth-grade class, students instinctively knew that the contour lines should not cross. They were very aware of this type of error in their model. When this type of problem occurred, the interaction between the groups was lively (to say the least!). First each group wanted to blame the other, and finally each group returned to the benchmark and measured its line again. Accuracy in measurements became important to the group leaders.

The students were very proud of their completed model. They took a few minutes in each class to observe it. They felt that their model closely represented a topographic map. Most felt that they had achieved better understanding of topographic maps.

The students also seemed to exhibit a little more respect for each other because most students took some role in the activity. The teamwork displayed in each class was inspiring—each group had constructed a line, but it took the entire class to have a completed model. ✧

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NOTE

This activity was developed as a part of RockCamp, a teacher enhancement project (NSF ESI-9155264) conducted by the West Virginia Geological and Economic Survey, West Virginia Department of Education, West Virginia University, and the West Virginia Coal Association.

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