

# Topographic Maps Teacher's Guide

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## I. **Module Description**

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- A. **Overview**- This module contains animations and interactive movies to help students interpret two-dimensional topographic maps using three-dimensional models. Students can view, interact with, and discuss different geological features. The main purpose of the module is to help students develop the spatial skills necessary to visualize three-dimensional landscapes from two-dimensional topographic maps. Three main landforms are used throughout the module: hill, valley, and cliff. The interactive movies created for this module allow students to increase the shading of a landscape, tilt and rotate landforms (to see both bird's-eye and side views), flood a landform with water, and slice into a landform to see profiles. Along with this teacher's guide, a **content guide** (for instructors) is also available to explain the terminology found within the module and to facilitate preparation of class materials. A **student guide** is available as a summary sheet for students to provide a brief overview of the module. The student guide will facilitate use of the module outside of class.
- B. **Rationale for Module** – Observations of students' interactions with topographic maps revealed that students have a difficult time interpreting and visualizing three dimensionality from the two-dimensional contour lines on topographic maps. This lack of success in visualization is believed to hinder students' success in numerous important field geology skills, such as locating their position on a map, correctly orienting themselves with respect to surface features, correctly interpreting surface features from contour line patterns (e.g., cliffs, valleys, and plains), and understanding what contour lines represent. Research on student understanding of topographic maps has shown that students often fail to 1) see the continuous change in slope between contour lines, 2) understand the relationship between spacing of contours (closely spaced or widely spaced) and slope of land (steep or flat), and 3) visualize the slope of the land from contours (Boardman, D., 1989; Eley, 1981; Eley, 1991). Presenting terrains with contour lines using a computer-based, interactive module is an effective way to allow students to manipulate and visualize terrains without having to go to a field area (Barsam and Simutis, 1984). Interactive, visual map presentations also improve students' abilities to find their position on a map and correctly orient a map (Schofield and Kirby, 1994).
- C. **Learning Cycle Approach** – The design of the module was modeled after the Learning Cycle approach (Lawson, 1989). This teaching method covers concepts in three phases: Exploration, Term/Concept Introduction, and Application. This module was constructed using this approach to encourage students to develop definitions and discover

connections between concepts rather than memorizing terms and definitions. The Exploration Phase allows students to interact with movies covering each main topic to develop a visual understanding first. This phase is followed by the Term/Concept Introduction Phase in which students are introduced to the appropriate terms and concepts for each topic. The Application Phase encourages students to integrate several concepts by solving a complex problem. These problems are open-ended, require students to use several concepts, and do not have a right or wrong answer.

- D. **Module Layout Synopsis** – Throughout the module, users will be presented with a still image of a topographic map on the left half of the screen, typically paired with a self-playing or virtual reality (VR) movie on the right half. Most screens in the module contain images on the left side with descriptions or questions for students on the right. As soon as users reach screens containing **self-playing** movies, the movie will pause while it finishes loading. When the movie is fully downloaded, it will play on a repeating loop. As the movie finishes, it will automatically start over from the beginning without the user having to click play. VR movies are presented with arrows above the movie indicating in which direction (left and right or up and down) the mouse should be clicked and dragged to produce the specified change (e.g., tilting, increasing shading, rotating, cutting into the profile, flooding a terrain, etc.). Single-headed arrows indicate in which direction the mouse should be dragged first to produce the change, and the change can be reversed by dragging in the opposite direction. For example, an arrow pointing up means the mouse should be clicked and dragged upward first, then dragged down to reverse the change.
- E. **Detailed Layout** – Upon entering the module after the opening screen, users are taken to a series of screens describing the content within the module. The introduction screens show example images of a topographic map on the left and a brief description of topographic maps on the right. This is followed by an image of a topographic map on the left and a description of contour lines on the right. Users are then introduced to 1) a VR tilt/rotate movie and 2) a self-playing terrain slice movie on two separate screens. Users then explore the landscape of a simple hill by viewing:
- 1) a VR shading movie (clicking and dragging up, then down) and
  - 2) a VR tilt/rotate movie (clicking and dragging up, down, left, and right).
- After interacting with these movies, users are asked a series of questions:
- Can you now envision what this terrain looks like, based on the map?
  - What is the hill's overall shape?
  - What are some of the finer details of its shape?
  - Is it the same steepness on all sides?
  - Is it aligned in some direction?

This exercise is included to enhance students' verbal description abilities and mimic tasks performed by field geologists. Additionally, users are asked to describe the landscape for someone who has never seen it before. They are then given a self-playing movie and example description written by a trained geologist using appropriate terminology. This process of movies, questions, and written descriptions is repeated for the valley and cliff landscapes.

The second section of the module introduces users to the water flooding movies for the three landscapes to reinforce the concept of contour lines and intervals. Users are asked

to predict how a landscape would flood, given a chance to interact with a flooding movie, and then asked to describe how an area floods by answering three questions: Where does it flood first? Where does it flood last? What pattern does the water make when it is half way up the slopes? A self-playing movie and example description are provided as examples for the first two landscapes but not the third.

The third section of the module introduces users to definitions of contour lines and index contours followed by movies showing profile slices of the same three landscapes. After each profile-slicing movie, a still image elevation profile is shown next to a topographic map. As part of the application phase, users are asked to visualize their change in elevation as they hike between two points on the topographic maps. Answer screens are included for some of the questions that show a self-playing movie and/or an example drawing of a profile between the two points. Users are asked to draw profiles for the hill, the valley, and the cliff.

## II. Learning Objectives and Questions for Discussion

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### A. Learning Objectives:

1. Students will be able to define contour lines and recognize that these represent a continuous elevation along a horizontal path.
2. Students will be able to calculate changes in elevation between contour lines.
3. Students will be able to explain the relationship between the spacing of contours and the slope of the landscape.
4. Students will be able to describe landforms with enough clarity and accuracy to have another student imagine the landform.
5. Students will be able to explain the correlation between landform shapes and shapes of contour lines (e.g., valleys are represented by a group of inward lines; cliffs are represented by closely spaced lines).

### B. Questions and Activities for Discussion:

1. Before opening the module, place a transparency of a topographic map on an overhead projector and ask students to note all observations about the landform. Students can be instructed to write observations, share and discuss them in a group and/or discuss as a whole class. A second transparency can be placed next to the first, and students can be asked to compare and contrast features of the two maps.
2. Ask students to predict what the surface of the land might look like for the two topographic maps above.
3. Ask students to reflect on the different landforms they viewed and to make connections between the shapes of contour lines and their corresponding terrain.
4. Upon completion of the module, ask students to examine contour maps of each landscape type and determine where they would build a village. During discussions, students should focus on ease of building shelter, finding water supplies, locations of natural resources, etc.

### III. Materials and Resources

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- A. **Time requirements** - The full module was originally developed for use in an undergraduate geology summer class and allotted 2-3 hours for completion. However, the menu-driven design of the module allows each section to be covered in separate 30-45 minute segments. The module was designed for use by groups consisting of 2 – 4 students to encourage discussion of ideas and interpretation of images, movies, and answers.
- B. **Movies** - The movies included in the module are one of two types: 1) QuickTime Virtual Reality (VR) movies that allow users to control movement and changes by clicking and dragging the mouse vertically and/or horizontally and 2) self-playing movies that begin playing on a repeating loop as soon as the movie loads from the CD or website.
- C. **Worksheets** - Worksheets were developed for this module to encourage active student participation. Preliminary observations of how students used the module showed tendencies for them to click through the module if not held accountable for the information. This was solved by including open-ended questions throughout the module and requiring students to complete a corresponding worksheet. Copies of the worksheets are included at the end of this guide and at the end of the student guide.
- D. **Programs needed** – The movies used throughout the module require QuickTime that can be downloaded for free from <http://www.apple.com/quicktime/download/>. For Guides and PDF Worksheet files, Adobe Acrobat can be downloaded from <http://www.adobe.com/products/acrobat/readstep2.html>.
- E. **Opening activities** – Before using this module, activities should be performed to help you and students understand the amount of prior knowledge students have about topographic maps. Open-ended discussions are one effective tool to determine students’ preconceptions in science (See section on questions for discussion; these questions can be asked before and after using this module to gauge understanding and progress). Other pre-module activities might include having students draw a contour map of a simple hill, using a “Volcano in a Box” activity (Piburn, et al., 2002), describing a feature to a partner and having the partner find it on a map, and molding clay to the shape of a landscape, inserting a plane into the clay, and tracing the line of intersection. Concept maps have also been shown to be an effective initial and continuing activity (Piburn and Baker, 1997). Concept maps can be altered as lessons progress to assess and monitor students’ conceptual understanding.

#### IV. **Creation of Module**

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- A. **Software used** – Movies for this module were rendered using the Corel Program Bryce. Individual images were then imported into VR Worx to create QuickTime VR movies. The layout of the module was developed in FrontPage 2000 using a menu-driven design to allow greater flexibility of use and navigation as well as greater teacher and student control of content coverage.
  
- B. **Computer requirements** for creating your own – The movie files and HTML codes were created on a PC. The basic software programs needed to begin are Bryce 5.0 (to generate movies), VR Worx (to convert to QTVR files), Microsoft's FrontPage 2000, QuickTime 5.0, and Adobe Acrobat 5.1.

## V. **Research and Evaluation**

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- A. **Assessment** – A spatial geology content test was developed for use as an evaluation tool to assess the effectiveness of this module and a module covering geologic blocks. The items included on this assessment emphasize the spatial skills necessary for interpreting topographic maps and subsurface geology.
- B. **Research** – This topographic maps module and a geologic blocks module were evaluated during a college-level summer course using control (no module) and treatment (using the module) groups. A summary of this research project (below) provides a description of findings and implications for how we found this module to be most effectively used.
- C. **Summary**

The complete details of the evaluation of the Hidden Earth project have been described in separate publications (Piburn et al., 2002; Piburn et al., in press). Consequently, we will include here only the most important details and results.

The evaluation was completed in four introductory geology laboratory sections taught during a summer session. Two were scheduled from 7 to 9 a.m. and two from 11 a.m. to 1 p.m. Each section was taught by a different teaching assistant. One section from each time was chosen as a control group and the other as an experimental group.

Students were pre-tested with two measures of spatial ability and with a geospatial test that was created to match the contents of the introductory laboratory manual. The experimental group interacted with the geologic block computer module and a topographic map computer module, but the control group did not. At the end of the five-week summer session, students in both the control and the experimental groups were tested again on all three instruments.

Both the control and experimental groups improved in their mastery of the laboratory material as evidenced by their scores on the geospatial test. However, there was a significant difference between those students who had completed the Hidden Earth computer modules and those who had not, with the performance of the experimental group exceeding that of the control group.

One indication of the difference between these groups is a comparison of normalized gain scores. Normalized gain is computed by dividing the amount of improvement (post-test minus pre-test) by the total room for improvement (total score minus pretest). Mean gain scores in the experimental group were 60%, while those in the control group were only 45%.

There were also important differences between the performance of males and females in the laboratories. There were significant initial differences between the genders on all instruments on the pre-test, with males more successful than females. However, by the end of the experiment scores of the two groups were identical. When gain scores were compared, females improved by 56%, while males only improved by 48%.

The spatial measures used in this study were the Cube Comparisons Test and the Surface Development Test, both taken from the Kit of Factor-Referenced Cognitive Tests published by Educational Testing Service (Ekstrom, et. al., 1976). In the first instrument, students were asked to rotate, in their mind, a cube with symbols on the sides. It is a measure of spatial orientation. In the second they were asked to fold a planar view of a figure into a three-dimensional figure. It is a measure of spatial visualization.

The Hidden Earth modules had no demonstrable effect on performance on the Cube Comparisons Test. However, there was a significant difference between control and experimental groups on the Surface Development Test, with the experimental group improving significantly over the control group. In a regression equation which included both measures, only the Surface Development Test explained a significant portion of the increased performance of the experimental group on the geospatial test.



## **VI. Dissemination**

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This module was originally developed for web-based distribution and later adapted for CD-ROM distribution (where internet connection is not required). The module was developed in Microsoft FrontPage, and is an executable, stand-alone program. Only QuickTime 5 is needed to play the movies in the module and Adobe Acrobat 5 to open the worksheet PDF files.

## References

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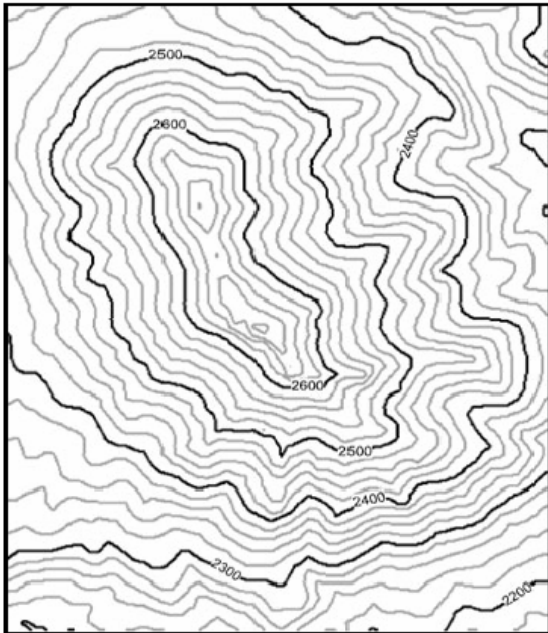
Schofield, N. J. and Kirby, J. R. (1994) Position location on topographical maps: effects of task factors, training, and strategies. *Cognition and Instruction*, 12(1), 35-60.

Name \_\_\_\_\_

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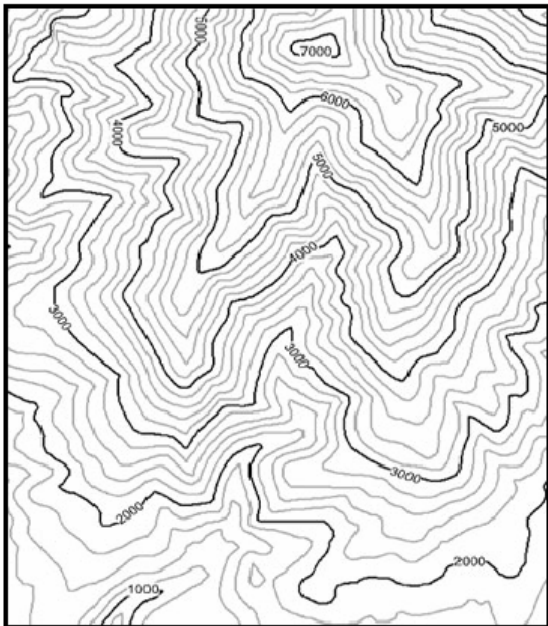
**CHAPTER 1 Worksheet 1A.** Work through the Visualizing Topography module on the computer. Put your observations and answers in the appropriate spaces below.

By now you have a picture in your mind of what this landscape looks like. In the space provided below, write a description of this landscape so that someone who had not seen it before could imagine it in their mind.



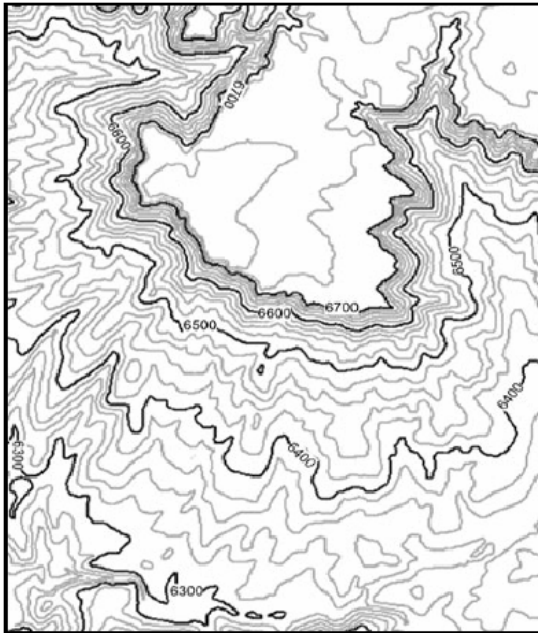
Landscape Description:

By now you have a picture in your mind of what this landscape looks like. In the space provided below, write a description of this landscape so that someone who had not seen it before could imagine it in their mind.



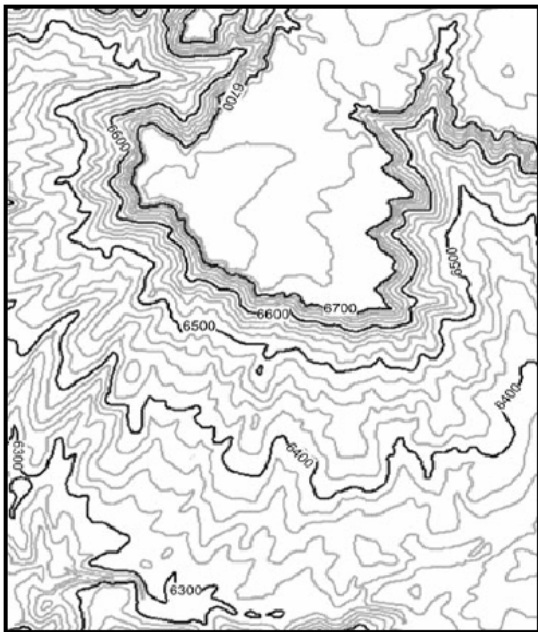
Landscape Description:

**Worksheet 1A (cont.)** By now you have a picture in your mind of what this landscape looks like. In the space provided below, write a description of this landscape so that someone who had not seen it before could imagine it in their mind. For this map, you will not be provided with an example of how you might describe this landscape.



Landscape Description:

By now you have a picture in your mind of how this landscape floods. In the space provided below, write a description of this landscape so that someone who had not seen it flood before could imagine it flooding in their mind.

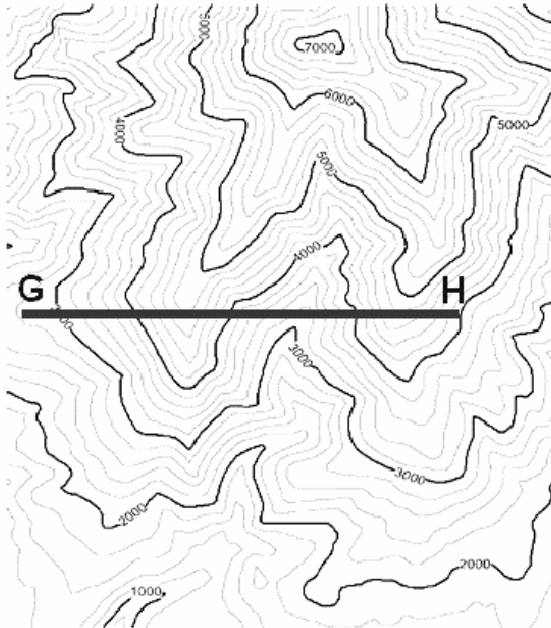


Landscape flooding description:

Name \_\_\_\_\_

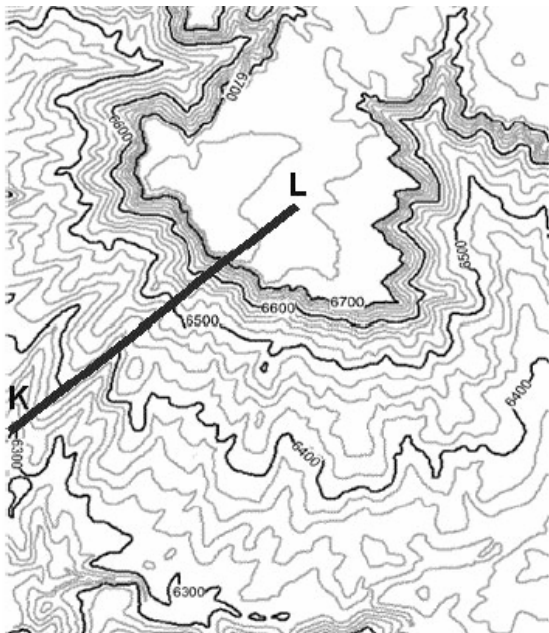
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Try to envision walking from G to H., especially when you are going up hill and when you are going downhill. Sketch the profile from G to H in the space provided to the right of the map.



Profile from G to H:

Try to envision walking from K to L., especially when you are going up hill and when you are going downhill. Sketch the profile from K to L in the space provided to the right of the map.



Profile from K to L: