The Graph Is Greener on the Other Side

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Overview

Topic: Interpreting Graphs. This lesson looks at the slope of a line as a rate of change. Students use the CBL and motion detector connected to the graphing calculator to discover how their walking speed affects the slope of a line. This exploration is followed up by a graphing activity in which students investigate the effect the shape of a container, in the process of being filled, has on the slope of the line. This activity also explores graphs based on the rate of fill (slope) of a vase as a function of the volume, height, and shape of the vase. Students then predict the shape of a variety of graphs based on given data. Prerequisite skills are knowledge of the coordinate plane, independent and dependent variables, and graphing ordered pairs.

Length of Lesson

3 50-minute sessions

Instructional Video/Technology

Math Vantage #14, Data: What Does It Mean?
TI-80, TI-82, or TI-83 Graphing Calculator
TI View Screen
Overhead Projector
HIKER program for graphing calculator
Calculator-Based Laboratory (CBL)
Vernier Ultrasonic Motion Detector
(Assessment) ***Interpreting Graphs*** (computer software) Dugale, S. & Kibbey, D. Pleasantville, NY: Sunburst Wings for Learning.

Learning Objectives

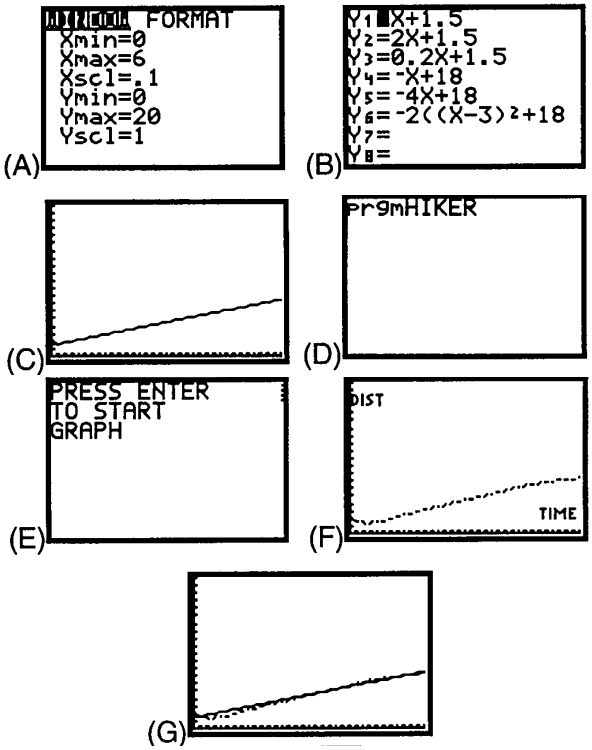
The student will be able to:
- replicate a given graph using the motion detector and CBL
- investigate the slope of a line as the rate of change (Va. SOLs Math A.7)
- collect, graph, and interpret data (Va. SOLs Science PS.1)
- use technology and mathematics to improve investigations (National Science Education Standards: Content Standards page 175)

Materials

- blank transparency sheets
- overhead pens

Per group of four students:
- 1 transparent vase or other container (vary the height and shape for each group)
- ruler
- measuring cup (Try out the size to make sure the vase does not fill too rapidly or too slowly. Film canisters (1 oz.) do well.)
- pitcher of water (or sand) to fill vases
- dark food coloring to color water (optional but makes measuring easier)
- graphing calculator
- Lab Sheet (attached)
- graph paper

Pre-Viewing Activities



(A) Hook up the motion detector, CBL, graphing calculator and overhead LCD panel. Set WINDOW to Xmin = 0, Xmax = 6, Xscl = .1, Ymin = 0, Ymax = 20, Yscl = 1.

(B) Enter the following equations in the overhead graphing calculator:

Y1=X+1.5 Y2=2x + 1.5 Y3=0.2x+1.5
Y4= -x + 18 Y5= -4x + 18 Y6= -2(x-3)^2+18

(C) Display the graph of Y1.

Ask the class: Who would like to come forward and try to walk this line? By controlling your walk, can anyone match this line plotted by the graphing calculator?

(D) Tell students that the motion detector sends out sound waves in a V-shape and the motion detector operates between a range of 1.5 and 20 feet. If they move out of the range, no points will be plotted. Student data will be collected for approximately 6 seconds. Turn on the CBL. Run the program ***Hiker***.

(E) To start the motion detector, you must press ENTER on the calculator and listen for the clicking sound which indicates that data is being gathered.

(F) Have the student try to move in such a way that the graph of his/her motions will match Y1's graph.
(G) If necessary, repeat the attempts until the student knows where and when to move. After the student's walk is graphed, press Y= and turn on Y1 by pressing ENTER on the = mark. (Each time the program ***Hiker*** runs it turns off all graphs.) Press GRAPH which will display both the line from Y1 and the line plotted by the student's walk.

(E) Discuss with the class ways to get the lines to coincide. Try again with other students and/or with other graphs. To recall ***Hiker*** program, press 2nd QUIT.

(F) Then press ENTER on the calculator and ENTER again to start the motion detector.

Ask: What does the x-axis represent? (time in seconds) and what does the y-axis represent? (distance in feet). What does the slope of the line represent? (rate in feet per second) Repeat the activity with other students and using the other equations until the graphs coincide relatively well and students understand that the faster they walk the steeper the line. The additional equations can also be used for the development of the concepts of negative slope (by walking in the opposite direction) and parabolic motion (by changing the direction of the walk).

Focus for Viewing

Say: Now that we understand that rate of change can be represented by the slope of a line we'll view a video that demonstrates a different situation. You will need to pay close attention in order to be able to describe what the graph represents.

NOTE TO THE TEACHER

Some segments of the video used in this lesson are very short. It is therefore suggested that practice with the pause control of the VCR would be extremely helpful.

Pause vs. Stop

When using a video interactively with students, teachers need to decide when to use **PAUSE** and when to use **STOP**. **PAUSE** the video when the anticipated discussion or activity will take less than two minutes. **STOP** for longer periods. Pausing for too long at one time can cause video heads on the VCR to become clogged which may require cleaning to correct.

Viewing Activities

1. **START** the ***Math Vantage*** #14 video at 1:55 where it shows pictures of various bar, pie, and line graphs. To help you cue into this section, the scene right before these graphs shows the female host stranded in the red car due to lack of fuel. PAUSE when the host says "Do you know what this means?" and **FRAME FORWARD** to get the entire graph to show on the screen then ask students to brainstorm about possible real-life situations this graph could represent.

2. Focus: Ask students to brainstorm about what information is needed in order to interpret graphs. **RESUME** the video and **PAUSE** after the host says "Put appropriate labels on the axes of the graph, give it a title, and show the situation." **REWIND** if necessary. Ask: What did the graph actually represent?

3. Focus: Now that we know the graph represents sipping soda, and the x-axis represents time and y-axis represents ounces, can you tell which is the independent variable (x) and which is the dependent variable (y)? Why? Let's look at the situation. **RESUME** the video to view situation represented by the graph. After the host finishes the second drink, **PAUSE** the video and ask students why a horizontal line was drawn each time she stopped to take a breath. (Time continued but no liquid was consumed.) Ask what the maximum values are that can be graphed on this particular graph.

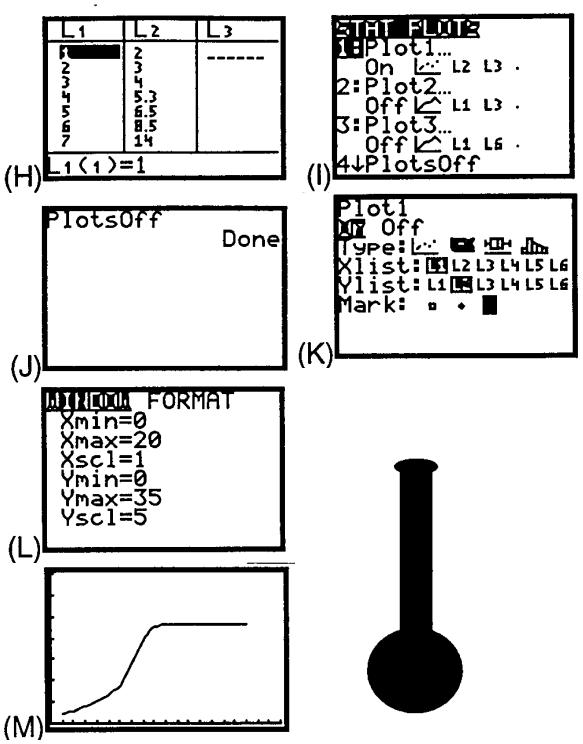
4. Focus: We will now look at one more situation and you will have to predict and sketch what the graph would look like. **RESUME** the video with the **SOUND OFF.** (This will keep the students from hearing the host say, "Can you tell why this graph makes a sudden drop?" But you also miss the elephant noise which can be a good audio cue for you.) When you see the elephant's trunk, **PAUSE** the video and have students draw their sketches of the predicted graph. **RESUME** the video with the **SOUND ON** and have students check their graphs against the one shown. **STOP** after the host summarizes the segment and states "These graphs make a lot of sense when you can see them being created as something is happening. Graphs give us a quick visual image of the situation." Say: Let's make something happen and graph the results.

Post-Viewing Activities

1. Give each group of students a graphing calculator, a ruler, some water, a measuring cup, and one transparent vase or container. Vary the heights and diameters of the vases between groups. Say: We will be investigating how the height of the water depends on the number of units of water added to the vase. Ask: What will the independent variable be and on which axis will it be graphed? (the number of units of water, on the x-axis) What will the dependent variable be and on which axis will it be graphed? (the height of the water, on the y-axis) What do you think the graph of the height vs. volume of your vase will look like?

2. Cooperative Tasks:

- Student 1: Record information into the graphing calculator. In L1, enter consecutive numbers, indicating the number of units of water added to the vase. In L2 enter the height of the water level (H).
- Student 2: Place the ruler up the side of the vase and measure the height of the water level after each successive addition.
- Student 3: Add units of water or sand to the vase.
- Student 4: Check to make sure the measurements are accurate and write down data points (number of units added and height) on the Lab Sheet.



3. Ask: What will the graph look like? What happens to the graph when the vase is full? Be aware that students may have trouble predicting what happens to the height of the water when the vase is full. Some will say the height of the water will increase; at that point get them to actually add another unit of water and let the vase overflow. This usually convinces them that the height remains constant from this point on.

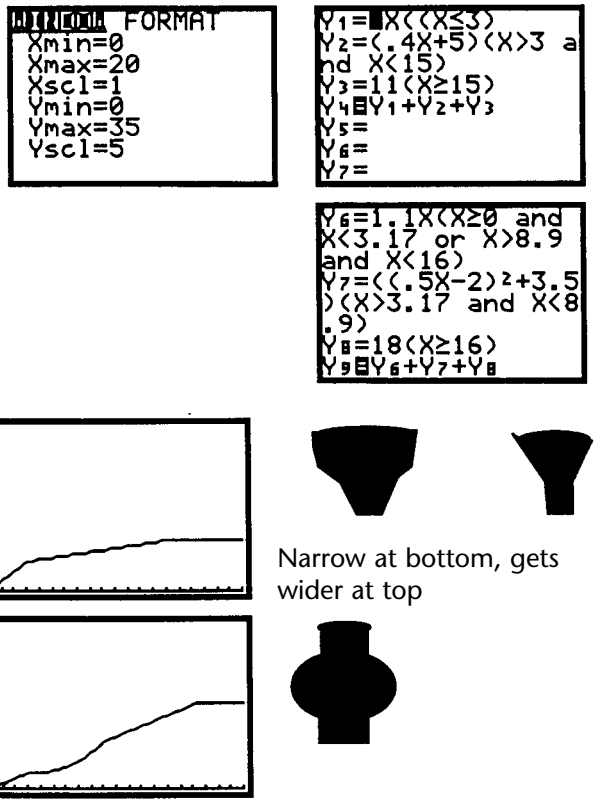
4. Once the vase is full and data is entered, go to Stat Plot (2nd Y=) (I) and turn all plots off (4 ENTER) (J). Then turn on Plot 1 (2nd Y=, ENTER, ENTER). Type should be line graph, Xlist should be L1, Ylist should be L2. Go to WINDOW and ask students what X (# of units) and Y (height of water) represent and set the appropriate values (L). (Xmin will be 0 and Xmax will be dependent upon the number of units of water added. Ymin will be 0, and Ymax will be dependent upon the maximum height. Scale could be 1 for each.)

5. Ask students to once again predict the shape of the graph then push the GRAPH button. Discuss the shape of the line vs. the shape of the vase. (M) After viewing each group's vase and the corresponding graph, ask students to predict the shape of the graph for a vase that is unusual in design. (Show them an odd looking vase.)

6. If time permits, consider negative slope by having students start with a full vase of water and remove water one ounce at a time and then plot the results of height vs. number of ounces removed. Ask students to predict what the graph will look like.

Assessment

1. Use these piece-wise functions to display graphs of possible shapes on the view screen. Have students predict the shape of a container that could have produced this graph.



2. Use the computer program, ***Interpreting Graphs,*** to give students a real-life situation where they need to identify which graph is a reasonable representation of the given situation.

Action Plan

1. Investigate the effect that changes in bottle design have on the fill rate for bottling companies. For example, when Coca Cola changed the shape of the 20 oz. drink to the original bottle shape, did they have to change the rate of flow of the drink when filling the bottles?

2. Have a glass blower talk to students about the process of creating containers. Investigate the correlation between the rate of blowing air into the vase and the resulting shape.

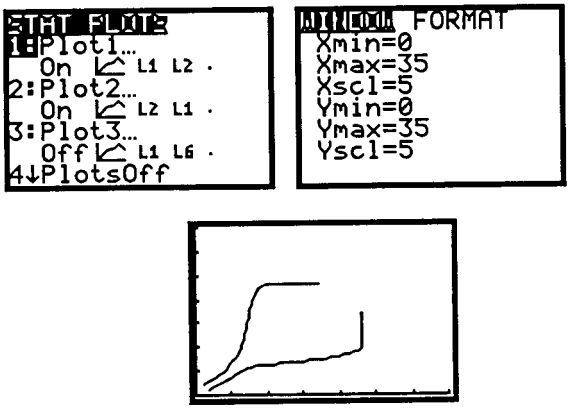
3. Invite an Investment Broker, Economist, or Statistician to visit and talk about how the use of graphs to predict trends is important in that career.

Extensions

Mathematics:

- Have students collect containers with unusual shapes, sketch the predicted graph, and perform the experiment to test each prediction.

- In the Stat Plot menu, switch the Xlist to L2 and the Ylist to L1. Explore the new shape of the graph.



- Have students use piece-wise functions to create a new graph and then ask other students to draw the vase that could have been used to generate a similar graph.

English: Ask students to create a story that can be represented by a given graph.

Economics and Social Studies: Have students bring in line graphs from publications and interpret the graphs.

Health: Have students investigate pediatric growth charts to discover when the growth rate of change was most rapid and when there was very little change.

About the Authors

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Bruce H. Hemp currently teaches pre-algebra, math 7, and exploratory classes in math art and rocketry at S. Gordon Stewart Middle School in Fort Defiance. During her 18 years of teaching, she has taught high school math and designed and implemented the math program at Valley Vocational Technical Center for students who had not succeeded in the normal classroom. Bruce holds a BA in Mathematics and Speech Communication from Westhampton College, University of Richmond, and an MEd degree in Mathematics from UVA. She has been a participant in the NASA Educational Workshop for Mathematics, Science and Technology Teachers (NEWMAST).

Donna H. Rosser
Donna H. Rosser is a mathematics teacher and MathCounts coach at Sandusky Middle School in Lynchburg. She has been teaching for 16 years and because of her dual certification in math and music has taught kindergarten through twelfth grade. Donna received leadership training in teaching with the graphing calculator through the Virginia Network for Technology program at Old Dominion University. Her main goal in teaching is to make mathematics come alive for her students through the use of manipulatives, technology, and writing about math. Donna received her Bachelor of Arts Degree in Mathematics from Westhampton College and her Masters of Music Education from JMU.

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LAB SHEET

Date _____

Name _____

What are the units you are using to fill the container? (ounces, cubic centimeters, tablespoons, 1/4 cup) _____

What units of measure are you using to determine the height of the water? (centimeters, millimeters, inches) _____

Number of units	Height
1	
2	
3	
4	
5	
6	
7	
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Predict the graph for this container. Be sure and label the graph.

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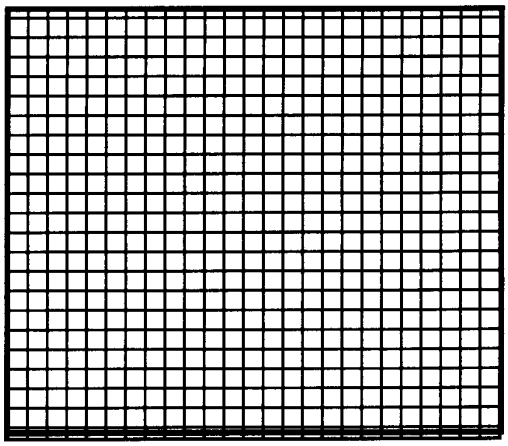

Predict the graph for your container. Be sure and label the graph.

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