The Biggest Box Activity

Modeling Non-Linear Data

A classic problem looking at maximizing volume by varying the height of a box. Uses graphing calculators to analyze data collected and to model a cubic equation. Look for points that maximize volume while developing a preliminary notion of families of cubics.

Mathematical Concepts Explored	Technology Used/Materials Needed	Commands/Functions Utilized
• Explore non-linear relationships • Problem solving using physical models • Work with volume formulas and develop an understanding of how changes in dimension affect volume • Graph a cubic equation • Practice setting up a list to build a mathematical model of a problem	• Student Worksheet • 2 pieces of 8.5x11 paper and 1 index card (3x5 or 5x7) for each group • Scissors, tape, rulers, centimeter or inch cubes or cereal to measure volume. • TI83+	• y= • graph/table • trace • formula

California Mathematics Content Standards Addressed by this Activity

5th grade

- Algebra and Functions 1.4 - Identify and graph ordered pairs
- Algebra and Functions 1.5 - Solve problems involving linear functions with integer values; write the equation and graph resulting ordered pairs
- Measurement and Geometry 1.2 - Construct a cube and rectangular box from two-dimensional patterns; compute the surface area
- Measurement and Geometry 1.3 - Understand volume and use the appropriate units to compute the volume of rectangular solids

6th grade

- Algebra and Functions 3.1 - Use variables in expressions describing geometric quantities
- Algebra and Functions 3.2 - Express in symbolic form simple relationships arising from geometry

7th grade

- Algebra and Functions 1.5 - Represent quantitative relationships graphically; interpret meaning of graphs or parts of graphs
- Algebra and Functions 3.2 - Plot the values from the volumes of three-dimensional shapes for various values of the edge lengths
- Measurement and Geometry 2.1 - Use perimeter, area (2-dimensional), surface area (3-dimensional) and volume formulas routinely

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Prior Knowledge

Students should be familiar writing variable expressions. They should also have some experience with the formula for finding volume. Students should also be familiar with using a graphing calculator in problem solving situations and making scatter plots using plot function.

Activity Agenda, Teacher Notes and Points for Discussion

Teacher will…	Student will…
1. Give students (in pairs) 1 piece of paper 8.5 x 11, scissors and tape. 2. Tell students they have to cut out 4 squares exactly the same size from each corner and fold the remaining paper into an open box. Tell students to use easily measurable increments (1/4 inch or 1/2 inch if using standard measure or 5mm if using metric measures). Demonstrate an example if students need to see one. Give students about 10 minutes to complete the task.	Student construct open box in pairs.
3. Ask the question "Who has the biggest box?" Clarify as a class that for this activity biggest means – greatest volume.	Participate in class discussion clarifying biggest for this activity
4. Demonstrate how to calculate the volume of the box used for the demo. After calculating volume verify the reasonableness of calculations by filling open box with centimeter, inch cubes or cereal and a graduated cylinder. Have students calculate the volume of their open box using a calculator.	Calculate volume of open box. Visually compare models with another pair of students. If available, use cubes or cereal to verify volume.

5. Distribute student worksheet. Have students collect data for various size cut out and their corresponding volumes.	Students collect data for various size cut out and their corresponding volumes. Students plot their data into the graphing calculator. Use Zoom 9:Zoomstat for graph window.
6. Have students use their graphing calculator to estimate the size of the greatest volume for the 8.5x11 sheet of paper.	Using the model and data, students determine an equation for calculating volume based on a cut out of x. Students enter their equation using the y= key to model problem. Use the trace key to find the box with the greatest volume. Students build biggest box based on their findings.
7. Discuss restrictions on the cutout value of x.	Participate in whole class discussion.
8. Have students extend the graph by lifting the restrictions on x. Have students adjust the window on their graphing calculator to see the entire function (use xmin=-10, xmax=10, xsc1=1, ymin= -100, ymax=75). Many students familiar with parabolas assume this portion of the graph is a parabola. By extending the graph the nature of the cubic function is more apparent.	Answer questions on worksheet.
9. Discuss any patterns the students see.	Participate in whole class discussion.
10. Extension: Repeat the same process as above for an index card.	Students repeat process for finding biggest box for an index card.

Extensions

Use the **TI Navigator** system to have students send cut out and volume data points to the class in activity center. Discuss as a class the shape of the graph and develop the equation. Assign groups different size sheets of paper. Have the groups develop their volume equations and send them to the class in activity center. Discuss the patterns noticed in the different volume equations. Finish the activity by sending students a learning check document.