



MODELING MANIA

Math Topic: Using Models

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ABOUT THE AUTHOR

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MATH TOPIC: Using Models

GRADE LEVEL: 4-5

TIME ALLOTMENT: Two to four 45-minute class periods

OVERVIEW: Whether the task is building a stage or a bridge, the CYBERCHASE kids use mathematics and problem-solving strategies to solve the toughest problems. CYBERCHASE is a daily, animated adventure TV series on PBS Kids that engages 8- to 11-year-olds in the fun and challenge of mathematics. In this lesson, students will view clips from the CYBERCHASE episode “Modeling Behavior” to examine the usefulness and applications of making models. They will then make their own models to solve a problem of a scientific nature—making a bridge that won’t collapse.

SUBJECT MATTER: Mathematics and Science

LEARNING OBJECTIVES: Students will be able to:

- Describe techniques helpful in solving spatial problems which utilize the notion that a model is a simplified version of something complicated;
- Describe that models can be used to easily and safely understand how something works;
- Utilize methods such as sketching or drawing possible solutions to a problem;
- Create a model requiring specific dimensions and materials.

STANDARDS: From the National Council of Teachers of Mathematics Standards, available online at <http://standards.nctm.org/document/chapter5/index.htm>

Representation

- To use representations to model and interpret physical, social and mathematical phenomena.

Geometry

- To use visualization, spatial reasoning, and geometric modeling to solve problems.
- To analyze characteristics and properties of two- and three- dimensional geometric shapes and develop mathematical arguments about geometric relationships.

MEDIA COMPONENTS:

Video

CYBERCHASE Episode #122: “Modeling Behavior”

Web Sites

Meet the CYBERCHASE Kids

<http://pbskids.org/cyberchase/meet.html>

Students have an opportunity to learn about the primary characters appearing in CYBERCHASE.

Super Bridge: Build a Bridge

<http://www.pbs.org/wgbh/nova/bridge/build.html>

Teachers may consult this site for additional information to enrich their basic understanding of bridge-building.

Super Bridge: Beam Bridges

<http://www.pbs.org/wgbh/nova/bridge/meetbeam.html>

Teachers may also use this site as an additional source on building other types of bridges.

MATERIALS:

(For the Class)

- Manila folders (See “Prep for Teachers” below for further information.)
- Scissors
- Hole punch
- Several boxes of paper fasteners (½-inch)
- Several boxes of wooden stirrers (preferably the small type)
- Several bottles of glue
- Several rolls of pennies
- Several centimeter rulers
- Paper towels
- Plastic bags

PREP FOR TEACHERS:

- Download the Shockwave plug-in, available at <http://www.macromedia.com> to computers that will be used during the lesson. **CUE** the videotape to the appropriate starting point, which is when the opera singer with the horned helmet is standing on platform singing. Prepare the handouts for the lesson by providing a copy for each student. Also, give each student (or small group of students) two plastic bags: Materials Set #1 and Materials Set #2 as described below.
- To read about what kids know and don't know about this lesson's math topic, please turn to the last page of this lesson.

MATERIALS:

Materials Set #1

- 25 strips (½ inch by 3 inches) cut from manila folders, with one hole punched close to each end of the strip
- 10 strips (½ inch by 6 inches) cut from manila folders, with one hole punched close to one end of each strip
- 25 paper fasteners

Materials Set #2

- “Building a Bridge” Activity Worksheet (reproducible provided)
- 30 wooden stirrers
- Several rolls of pennies
- Centimeter ruler
- Paper towels
- Have the glue available when beginning the Culminating Activity, but do not include the glue in the bag of Materials Set #2. This will encourage the students to complete the Activity Sheet and make their sketches before beginning assembly of their model. Once they have shown their completed handout and sketch to the teacher, then the teacher may issue the glue.

- When using media, provide the students with a **FOCUS FOR MEDIA INTERACTION**, a specific task to complete and/or information to identify during or after viewing video segments, Web sites, or other multimedia elements.

INTRODUCTORY ACTIVITY:

The world of mathematics is one that works in tandem with science. This lesson is designed to show students how valuable it is to use models to solve problems. Students will build a model of a bridge, and then test it for strength. The activity begins with a discussion about what a model is and how models are used in the real world.

1. Ask students: **Have you ever seen a model of something? What kind of model was it?** (*Accept answers.*) **What are some other examples of models?** (*Students answers will vary; they may answer with examples of model airplanes, model cars, architectural models, etc.*) **What is the difference between a model and the thing it represents?** (*A model is simpler, cheaper, and smaller. It is a simplified version of something complicated that allows you to easily and safely understand how it works.*) **Why do people sometimes build models before building the real thing?** (*Cost, size, effort. It's easier to make a change to a model than to make a change to a real thing. A model can help you see how something will work. Also, a model is portable. You can easily show it to others.*)
2. Tell the class that later on in the lesson, they will be building a model of a bridge. But before they get started, it is important to discover shapes that make a structure strong. Ask the students to make simple shapes using the materials in the bag (Set #1). The shapes they construct out of the paper strips and fasteners should include, but should not be limited to, a square, parallelogram, pentagon, and triangle. Tell the students to try to create as many flat shapes as possible given the materials in front of them. Allow students to punch additional holes in the paper strips to create their shapes. Ask them to show the shape to the class by raising it up in the air when finished. As students share their shapes, have them also describe what shape they have made.



Ask them to investigate which shape is the strongest — which holds its shape when you try to make it collapse? (One way to test a shape is to hold it upright and push down on it.) Ask: **Which shape is the most rigid? Is a square rigid? Why or why not?** (*A square is not rigid. It collapses.*) You might want to point out that as the square collapses, it forms a shape (a rhombus) that still has four equal sides, but the angles are not right angles. Ask: **Is a rectangle rigid?** (*No, It also collapses easily.*) **How about a triangle?** (*Triangles seem to be the strongest — the most rigid — of the paper shapes, and can't be collapsed as readily.*) **Might a triangle be a useful shape to use when building a model of a structure?** (*Yes.*) If students made a pentagon or hexagon, discuss them at this point. Note that they both collapse and are not rigid. Ask: **How could you make the square or rectangle more rigid?** (*Add supporting braces.*)

3. Explain to students that they have just used models to explore which shapes are strong and which are not. Their models helped them discover some of the geometric characteristics of the shapes. Before the class begins building their own models of a bridge, they will examine how the CYBERCHASE kids use models

to solve their problems. At this point in the lesson, have the students place their shapes and extra strips back in the bag to lessen distraction during the video.

LEARNING ACTIVITY:

The CYBERCHASE episode “Modeling Behavior,” will help emphasize some of the concepts introduced in the Introductory Activity.

Provide the students with a **FOCUS FOR MEDIA INTERACTION**, asking them to log on to the “Meet the Characters” page of the CYBERCHASE Web site at <http://pbskids.org/cyberchase.meet.html> and look at the page and list the main characters. This will allow the students to become more familiar with the characters. If the students are familiar with the characters, this step may be skipped. After students have viewed the site, their list of characters should include: **Inez, Matt, and Jackie** (The CYBERCHASE kids), **Digit** (their sidekick, a talking bird), **Motherboard and Dr. Marbles** (guardians of Cyberspace), **Hacker** (the villain, out to destroy the Motherboard and gain control over Cyberspace), **Buzz and Delete** (Hacker’s henchmen)

1. **CUE** CYBERCHASE #122: “Modeling Behavior” to the point of the video where an opera singer with a horned helmet is standing on a platform singing. Provide the students with a **FOCUS FOR MEDIA INTERACTION**, asking them to describe the problem the CYBERCHASE kids have encountered with the table. **PLAY** the tape.
2. **PAUSE** the tape when the platform topples over the first time and the town crier says, “Hear ye, hear ye. The platform has collapsed and the wicked witch is not happy.” Ask students why the platform did not support the wicked witch? Ask: **What would be a logical plan of action in solving the problem?** (*Students should brainstorm for possible solutions and choose the most logical.*) **What would you suggest to the CYBERCHASE kids to help them solve the problem with the broken platform?** (*Listen to student suggestions but do not correct them yet.*) Let’s see if the CYBERCHASE kids will follow the class’s suggested solution of fixing the table.
3. Provide your students with a **FOCUS FOR MEDIA INTERACTION**, asking students to determine why the CYBERCHASE kids’ solution doesn’t work. **PLAY** the video. **PAUSE** the video when the platform falls for the second time. Check for student comprehension, and have students state what was wrong with the CYBERCHASE kids’ solution (*Allow students time to fully describe the solution; this is as important as completing the problem*). Ask: **What shape is formed by the legs of the platform, the platform and the floor?** (*A rectangle*) **And what do we know about rectangles?** (*They collapse.*)

Have students pull out the geometric shapes they formed in the Introductory Activity and review that the triangle was the only shape that makes a figure rigid. Ask: **How can you make the other shapes rigid?** (*Add internal supports or braces on a diagonal, thus making the shape supported by rigid triangles.*) Have students make the square rigid. For example, have the participants use the longer strip to make a brace for the square. Fasten one end and then cut the strip so it ‘fits.’ Punch a hole in this end and attach. Note that this creates a diagonal that forms two triangles. Point out that the square is now rigid!

Discuss how the use of a physical model helped test the mathematical idea that solved the problem. Discuss the different ways the braces could be placed and

the importance of a model. It can be changed or modified easily, cheaply, quickly, and safely.

Students may also choose to could also make their other shapes rigid by adding internal braces at this point in the lesson.

4. Provide your students with a **FOCUS FOR MEDIA INTERACTION**, asking your students to determine if Jackie's solution is similar to their solution for strengthening the paper shapes. **PLAY** the video until the CYBERCHASE kids reinforce the platform with the additional boards. **STOP** the video when the three pigs are holding hands, spinning around, and singing, "Ashes, ashes, we all fall down." Ask: **Were any of your models close to or just like Jackie's model? How was Jackie's experience with the model different from Matt and Inez's experience with trying their ideas on the real thing?** (*Jackie didn't use a physical model. She used a computer model, the Sqwak Pad, and was able to change certain things to solve the problem. This was a computer model, which functions like a physical model. The kids used the real pieces of the platform, which took considerably more time, and wasn't very safe.*) **Whose job is easier? Who gets to the solution faster?** (*Student answers will vary.*)

CULMINATING ACTIVITY:

1. Tell students to imagine that the President of the United States is holding a contest and would like for the class to engineer the creation of a new bridge over the Potomac River in Washington, D.C. The bridge must be very sturdy. He is seeking the most outstanding engineer, who can create the strongest bridge. The only problem is that the bridge must not cost a lot of money. Keeping cost in mind, it would be in the best interest of the President and his budget to make a model of the bridge rather than make many mistakes while building the real bridge. The winner of the best bridge (strongest yet costing the least) will receive the Presidential Award of Engineering. The winner will be determined by how many rolls of pennies the bridge can hold before breaking.
2. Give each student or group Materials Set #2, and distribute the "Building A Bridge" worksheet to each student.
3. The handout lists the exact dimensions the bridge should be built using only the materials in the bag. The criteria are as follows:

Length of the bridge:	30 cm long
Width of the bridge or roadbed:	5 cm wide
Height of the bridge or clearance:	10 cm tall
Cost of the bridge:	\$10 per wooden stirrer (students may opt to use additional stirrers but the cost of the bridge will increase with each stirrer).

A note about the materials: The bridge must be constructed at school using only the materials in the bag or the glue issued. No other reinforcing materials may be used. Wooden stirrers can be broken to construct the bridge. Remind students that they will need to keep track of the total number of stirrers in their bridge.

4. To prevent students from moving ahead with the building process, retain all the bottles of glue until they have filled out the questions on the handout. This will

reinforce problem solving and encourage them to create a sketch before building. Review with students the concepts the CYBERCHASE kids used in building reinforcements on the platform. (*Determining the problem, brainstorming a solution, making a sketch showing how all the parts fit together, and building the model and testing it.*) Students may wish to visit the bridge Web sites listed at the beginning of this lesson for inspiration and ideas.

5. Have students sketch out their ideas for their bridge. Students may manipulate the wooden stirrers around to help give them ideas for their sketch. Once the students have shown the teacher their handouts and a sensible sketch, give them the glue.
6. The building process may take more than one class period. Some of the wood pieces will need to dry before completing the construction. One of the questions on the handout asks the students to describe what parts of the bridge will be constructed on Day 1, and what parts will be built on Day 2. This helps the student to know that the bridge will need drying time before proceeding to the next part.
7. Set up for the bridge test by pushing two desks close together (not touching). Place a bridge on the two desks so the ends of the bridge rest on each edge of the desks, spanning the gap between. Make sure each bridge tested has the same amount of bridge surface touching each desk. Begin placing rolls of pennies on the bridge. When the bridge breaks, have the students record how many rolls of pennies their bridge was able to hold. Be sure to thoroughly tape up the rolls of pennies so they don't fall all over your classroom floor.
8. Have students complete their worksheets and write on the board the cost of their bridges and the number of rolls of pennies the bridges held. Ask students if their sketches were helpful in the construction process. (*Students will offer a variety of answers.*) Ask your students how they would modify their model or bridge? (*Listen to student responses.*) Award the student with the most outstanding bridge based on the criteria listed above (*most cost efficient, held the most weight*). Ask students to describe what they discovered about bridge-building, how they would change their approach if they could do it again, and how making a model made it easier to test the strength of the structure rather than building the real thing.



CROSS-CURRICULAR EXTENSIONS:

- **Art.** Students can research different shapes and designs of bridges. Have student draw versions of their model incorporating unusual yet useful materials into the overall design of the bridge.
- **Social Studies.** Students may want to research how the existence or destruction of bridges have been instrumental in numerous wars (i.e. Civil War, World War I or II, etc.) The following Web sites might be useful in composing a report on such a topic:
 - The significance of building temporary pontoon bridges in the Civil War <http://www.kenmore.org/farmcivilwar.html>

- Throughout World War II in the Pacific, North Africa, and Europe, high-performance medium bombers were employed successfully against bridges destroying them and the enemy's access to American troops.
<http://www.nasm.si.edu/galleries/gal205/gal205.html>

COMMUNITY CONNECTIONS:

- Research occupations that require model-building.
- Create a list of places in your community where architectural models are showcased.
- Invite an architect or engineer to your class to discuss how they use models.



NAME _____

1. Bridge Requirements:

Length of bridge: 30 cm long
Width of bridge or roadbed: 5 cm wide
Height of the bridge or clearance: 10 cm tall

*Must be built with wooden stirrers and glue. No other materials can be used.

Cost per stirrer is \$10

2. On a separate sheet of paper, draw a picture of the bridge you would like to make. Label it "[Your name]'s BRIDGE." Include in the sketch any wooden stirrers you will use to build the bridge. Use a pencil for your sketch in case you decide to make changes. Remember: It is better to modify your sketch rather than make mistakes with actual "costly" wooden stirrers. As your bridge develops and you modify your ideas, make any changes to your sketch as needed.

3. Daily Building Goals:

These are the parts you wish to glue together on Day 1:

These are the parts you wish to glue together on Day 2:

4. Total Cost of Bridge _____

5. How many rolls of pennies the bridge held _____

Math Topic: Using Models

(To go with “Modeling Mania”)

What we can assume 8- and 9-year-olds already know about USING MODELS:

Kids build physical models of cars, boats, planes, and doll houses. They participate in science fairs and build model solar systems, volcanoes and molecules to represent the features they want to highlight for their displays. They realize that a model is a simplified version that is missing key features not needed for their study.

What confuses kids about USING MODELS:

Outside of the classroom, kids do not have a lot of experience using models to create and observe a particular feature, such as making a model to test strength or safety of a construction. Nor do they have experience using them to perform experiments to find out if something they want to make or do is viable or not.

They need help understanding that because a model behaves in some ways like the real thing, it can be used to make predictions and anticipate results. For example, in a problem called ‘the traveling salesman,’ the goal is to find the shortest possible route to destinations scattered across town so you don’t have to cover the same route twice (which would waste a lot of time and gas money). You make a ‘model’ by replacing the real map of the town with a bare-bones sketch that shows just the points that represent the various destinations. As you study the relative distances between the points, you make guesses, drawing lines as you do so, about different routes you might follow. You measure and compare distances, adjusting your path as needed, until you find the shortest route.

Or say you want to design a marble chute that will make a marble roll a distance greater than your friend’s marble chute, and in less time. Before making the real thing, you make different models to examine different parts of the challenge. You build ramps, for example, to figure out the best possible angle of incline (which you measure with a protractor) and to get the greatest distance (which you measure with a tape measure). You also use a stopwatch to find the ramp that does this in the shortest amount of time. Then, given what you know from your separate investigations, you combine what you’ve learned to build a version to see how your design works.