BUILDING BIG AND STRONG

MASTER TEACHERS	Emalie Egan and Lori Gribble
LESSON TITLE	Building Big and Strong
GRADE LEVELS	Grades 6 – 9
TIME ALLOTMENT	Two 60 minute class periods
OVERVIEW	Students will explore the concepts of architectural rigidity and apply knowledge of triangles to problems affiliated with construction and engineering.
SUBJECT MATTER	Math, Science, Engineering
LEARNING OBJECTIVES	The students will be able to: Analyze various polygons for properties of architectural rigidity. Explain why some shapes add more rigidity than others. Predict the effect of force on various small structures. Draw cutaway pictures that demonstrate knowledge of the use of triangles to increase architectural rigidity.

STANDARDS

National Standards:
http://www.nctm.org
Students will communicate their mathematical thinking coherently and clearly to peers, teachers, and others.
Students will analyze and evaluate the mathematical thinking and strategies of others.
Students will use the language of mathematics to express mathematical ideas precisely.
Students will select and use various types of reasoning and methods of proof.
Students will solve problems that arise in mathematics and in other contexts.
Precisely describe, classify, and understand relationships among types of two- and three-dimensional objects using their defining properties.
Examine the congruence, similarity, and line or rotational symmetry of objects using transformations.
Recognize and apply geometric ideas and relationships in areas outside the mathematics classroom, such as art, science, and everyday life.

State Standards:
Tennessee State Framework:
Spatial Sense and Geometric Concepts
In order to develop Spatial Sense and an understanding of Geometric Concepts, the mathematics curriculum must include problems which require students to explore geometric properties and relationships and to investigate, model, and analyze one-, two-, and three-dimensional figures.

MEDIA COMPONENTS

Video
PBS Series: Building Big : "Thinking Big and Building Small"
Web Sites
http://www.pbs.org/wgbh/buildingbig – An interactive site for educators and students focusing on engineers and engineering activities.

MATERIALS

Per Class: Examples of cutaway drawings (David Macaulay's books are excellent resources for this lesson. Science textbooks have many cutaway drawings as well.)

Per Group: 36 straws, 72 small paper clips, Internet access

Per Student: Large piece of drawing paper, pencils

TEACHER PREPARATION

Cue video to the image of the hurricane building in the Caribbean. This is approximately 15 minutes into the video.

Bookmark and explore http://www.pbs.org/wgbh/buildingbig.

Organize students into cooperative groups of three or four.

Write the steps of the Technological Design Process on the board: Identify a challenge, Brainstorm, Design a Solution, Test ideas, Build it, Evaluate

INTRODUCTORY ACTIVITIES

Step 1. Ask students if they have seen storm damage in their area, and if so, to describe it. Tell them that they are going to watch a few seconds of some very disturbing footage of a small house in a hurricane. **TO GIVE STUDENTS A FOCUS FOR MEDIA INTERACTION**, ask them to observe carefully and see if they can create a slow motion movie in their imagination of how this building is affected by the force of the wind. **FAST FORWARD** Building Big: "Thinking Big and Building Small" to a visual of a Caribbean hurricane and a house; the audio is " . . . a hurricane named Ella." **PAUSE** the video to check for comprehension at the collapse of the house. Ask students to describe what happened to the house. **REWIND** and **REPLAY** the video segment. **PAUSE** continually to allow students to observe the step-by-step destruction of the small white house. **STOP** the video when the house collapses to connect the segment to an engineering concept. Explain to students that the house was basically a box shape, or essentially a rectangular prism. What happened to the house/rectangular prism in the storm?

Step 2. Direct students' attention to the school building structure. Ask them what keeps it from falling down. Lead them through the following questions and discussion, recording responses on the board. We have had rain and wind, and this building still stands. What is keeping it up? What polygons (closed, convex shapes) do you see? What shapes are there in the gym and the cafeteria? (Often more ceiling beams and other structural elements are exposed in large rooms.) How many sides does that polygon have? How many vertices (corners or joints)? How many angles? Create an organized chart on the board of names of polygons, numbers of sides, and numbers of vertices.
For example: Triangle – 3 sides – 3 vertices – 3 angles,
Quadrilateral – 4 sides – 4 vertices – 4 angles
Students may not see very many polygons, even in the cafeteria and the gym; so encourage them to name all the polygons up to the octagon.

INTRODUCTORY ACTIVITIES (cont'd)

Step 3. Write the words, "architectural rigidity" on the board. Ask students to speculate on the meaning of these words. Explain that they will be testing some polygons for architectural rigidity. Remind students that structures must bear the load of the structure itself, the roof, the floors, and the walls. Demonstrate how to build a polygon. Create a vertex by linking two paperclips; then, slip the paperclips into the ends of two straws. Distribute straws and paperclips to groups. Allow students time to make predictions, build and test their polygons. To test the polygons, students will apply pressure to the top to check for rigidity. Record results.

LEARNING ACTIVITIES

Step 1. Ask students to reflect on the results of their previous experiment. Which shape has the greatest architectural rigidity? They should see the triangle as having the greatest architectural rigidity. Ask students if they think skyscrapers move. If so, have they ever observed it happening? Explain to students that they are going to watch a few more minutes of video to make some predictions about decisions that some civil engineers had to make regarding architectural rigidity, safety, the sway of the building, and admitting mistakes. Refer to the Technological Design Process written on the board. **TO GIVE STUDENTS A FOCUS FOR MEDIA INTERACTION**, ask them to pay attention to the ways that the engineers use the Technological Design Process. **REWIND** video and **BEGIN PLAY** at the beginning. **PAUSE** as the animated table collapses to highlight a point and make predictions. Ask students what polygon has the most architectural rigidity. Ask students to predict what polygons the civil engineers and architects will incorporate into the design of this building.

Step 2. **TO GIVE STUDENTS A FOCUS FOR MEDIA INTERACTION**, ask them to watch the next demonstration so that they can duplicate with their materials. **RESUME PLAY**. **PAUSE** when the animated square is shifting from side to side to replicate the demonstration. Once the students have completed their replication, lead them through the following discussion. Will adding squares increase architectural rigidity? Did you predict the addition of triangles and strengthening the vertices?

LEARNING ACTIVITIES (cont'd)

Step 3. Tell students that Mr. LeMessurier faced a serious question about the safety of his building. Instruct them to watch what happens when Mr. LeMessurier finds a problem with his building. **RESUME PLAY**. **PAUSE** to make predictions when the audio is "What should LeMessurier have done?" The visual is a large yellow question mark. Ask students to predict what Mr. LeMessurier should do now that he has found that the joints are too weak. How should they be strengthened? **TO GIVE STUDENTS A FOCUS FOR MEDIA INTERACTION**, instruct students to compare their predictions with Mr. LeMessurier's solution. **RESUME PLAY**. **STOP** the video to make real world connections when the "Thinking Big" segment ends. Ask students what polygon is the most important in adding architectural rigidity and safety to large buildings.

Step 4. Tell students that they are going to test the strength of some different shapes; unlike the straw activity from earlier these are not all polygons. Ask students to log onto www.pbs.org/wgbh/buildingbig, and select the interactive lab area. Ask them to choose the "shapes" lab. **GIVE STUDENTS A FOCUS FOR MEDIA INTERACTION** by asking them to work as a group through each of the activities for all three shapes. Have them record findings. As groups finish, ask them to share their findings and apply the concepts to a real world application, like the one from the final scene of the video.

CULMINATING ACTIVITY

Step 1. Explain to students that they are going to be the architects and engineers in the next activity. Distribute drawing paper. Refer to the Technical Design Process on the board. Instruct them to use the Technical Design Process to design a playground for our city. Review the steps from the video. Have them decide who, in their group, will design which structures for the playground, and how these structures will interact. This is the challenge: Follow the process through step three today, and design a solution. It may help groups to decide on a theme for the playground. (Help students manage their time so that they brainstorm and still have time to draw.)

Step 2. When students have completed their plans, or at least made some progress, allow time for students to share their ideas with other groups. Close the lesson with a class discussion and a real world connection. Remind them that they explored one of the big ideas in engineering and construction: the importance of triangles in architectural rigidity. Ask them to look for examples of the use of triangles in the structures that they observe on their way to and from school before the next class period.

CROSS-CURRICULAR EXTENSIONS

Math
Students may use straws to explore which combinations of lengths will make triangles.
Students may explore the Pythagorean Theorem.

Social Studies
Students may explore the importance of public buildings in our history. They may also research some of the engineers and engineering feats, or challenges that were faced in erecting these structures.

Science
The companion video segments, "Building Small", provide a variety of projects exploring force and measurement.

Language Arts
Students may visit the web site
http://www.pbs.org/wgbh/buildingbig to
research the biographies of some present day architects and engineers.

COMMUNITY CONNECTIONS

Students may visit local structures and study local architecture.

The class may invite the architect, or engineer of the school building (or some other local structure) to come to speak about engineering and safety decisions.

Students may call tour bus companies and ask which are the most popular places to visit in the community.

Students may make maps for visitors to the area of local buildings of interest.

STUDENT MATERIALS

No additional materials.