BRIDGE UP!
ENGINEERING

LESSON 4 – GRADE 4

LESSON 4 – GRADE 4: Geometry in Bridge Design

Big Idea

Students will identify bridge designs and the shapes most often found in these designs. They will use this knowledge to create a structure that will sustain weight bearing to explore the reasoning behind the use of these shapes.

Essential Questions

What are the key shapes found in bridges around the state?

Why do these specific shapes get used so often in bridge construction?

Background Information

Around 20,000 bridges span various locations in Minnesota. Of these bridges, about 200 are considered historic bridges (**http://www.dot.state.mn.us/bridge/) (http://www.dot.state.mn.us/historicbridges/**).

Standards & Benchmarks

Minnesota Math Standards: Geometry and Measurement

4.3.1 Shapes

Name, describe, classify and sketch polygons.

Benchmark: 4.3.1.1 Triangles

Describe, classify and sketch triangles, including equilateral, right, obtuse and acute triangles. Recognize triangles in various contexts.

Benchmark: 4.3.1.2 Quadrilaterals

Describe, classify and draw quadrilaterals, including squares, rectangles, trapezoids, rhombuses, parallelograms and kites. Recognize quadrilaterals in various contexts.

4.3.2 Angles

Understand angle and area as measurable attributes of real-world and mathematical objects. Use various tools to measure angles and areas.

Benchmark: 4.3.2.2 Compare & Classify Angles

Compare angles according to size. Classify angles as acute, right and obtuse.

Minnesota Science Standards: The Nature of Science and Engineering

4.1.2.2 Practice of Engineering

Engineering design is the process of identifying problems, developing multiple solutions, selecting the best possible solution, and building the product.

Benchmark: 4.1.2.2.1 Designs for Solving Problems

Identify and investigate a design solution and describe how it was used to solve an everyday problem.

Wisconsin Math Standards
4.MD.6 Geometric measurement: understand concepts of angles and measure angles.
Measure angles in whole-number degrees using a protractor.

4.G.2 Classify 2-dimensional figures based on the presence or absence of angles.

Wisconsin Science Standards
Science Connections: *A.4.2* When faced with a science-related problem, decide what evidence, models, or explanations previously studied can be used to better understand what is happening now.

Nature of Science: *B.4.1* Use encyclopedias, source books, texts, computers, teachers, parents, other adults, journals, popular press, and various other sources to help answer science-related questions and plan investigations.

Science Inquiry: *C.4.2* Use the science content being learned to ask questions, plan investigations, make observations, make predictions, and offer explanations.

Connections with Multimedia Program
Bridge Up! Geometry in Engineering
Bridge Up! iBook

Activity Description
In part one, students will look at images of existing Minnesota bridges and identify/tally the geometric shapes used in a variety of bridges. They will also identify angles used in the bridges. Part two of this activity was adapted from a Scholastic Engineering Activity on Bridge Design. Students will build bridge structures and identify how geometry (such as triangles, quadrilaterals, i-Shape and arches, and angles) affects bridge design and function. Students will track data either in groups or as a whole class using a chart/table. (Maximum weight, number of popsicle sticks, bridge type, geometric design used, and the positive/negative of their structure type.)

Vocabulary

See **http://www.dot.state.mn.us/stcroixcrossing/design.html#deck**
for specifics on the St. Croix Crossing Bridge Construction

Bridge deck – The surface of a bridge where vehicles and pedestrians travel.

Superstructure – This is made up of the deck, railings and any beams.

Substructure – This is made up of the piers, abutments and walls.

Acute angle – An angle with a degree measurement greater than 0 but less than 90.

Obtuse angle – An angle with a degree measurement greater than 90 but less than 180.

Right angle – An angle with a degree measurement of 90.

Straight angle – An angle that measures 180 degrees.

Truss bridge – This bridge type has a superstructure composed of elements connected to form triangles.

Arch bridge – A bridge made from one or more arches and abutments.

Beam bridge – Beam bridges are made of a flat piece, or beam, laid across two or more supports.

Suspension bridge – A bridge made of a platform that is held up by wires or ropes strung from the tops of piers.

Live load – Temporary loads on a bridge, such as automobiles or pedestrians.

Materials

Part 1:

- Picture cards (teacher will have to make these) OR
  Website with Minnesota bridge pictures
    - **http://www.dot.state.mn.us/historicbridges/search.html**
    - Google: Images of Minnesota and Wisconsin Bridges
- Protractors

Part 2:

- Popsicle sticks
- Glue
- Duct tape
- Metal washers for the weight bearing
- Design sheet
- Data collection sheet

Procedure

Part 1:

- Students will be provided with pictures (either on laminated cards or internet) of various bridges to identify geometric shapes (arches, triangles and rectangles) within each bridge.
- Students will tally which shape and how many times they see each shape on the various bridges. Have students discuss in small groups or with partners why engineers might choose to use the various shapes – this is a basic introduction.
- Next, introduce the bridge types and shape specific names for the various bridge types. Students can find some of these bridge shape names on the MnDOT Bridge website: **http://www.dot.state.mn.us/bridge/**

Part 2:

- Challenge students in groups of 3-4 to build a bridge structure that will withstand the greatest amount of load (weight).
- Students will first discuss/brainstorm which bridge type they want to design or the teacher can assign each group using a specific geometric shape or combination of shapes to build their bridge.
- Students will draw/design the bridge in their science notebooks or on the provided design sheet.
- Students should include a bridge deck to their design for the testing process.
- Students will gather materials and build their bridge allowing for drying time. During this time, teacher will walk around asking questions about student design, why they chose it, etc.

Part 3:

- Student groups will test the bridges using weights. Use pre-determined weights (pennies or metal washers from FOSS kit) to keep variables the same per group. Track the data as weight/load is added to the bridge deck. This would be done as a whole group and students will test their bridges one at a time.
- Watch for sagging and fracturing as additional weight/loads are added to the platforms.
- If the structure breaks or fractures, that is considered a "failed" design. On the worksheet provided, students will discuss and think about why the bridge could not hold the weight/load and what they would do differently to improve the design.

Assessment

Teacher can use the worksheets provided and observations throughout as a formative assessment.

Extensions

Students can also identify acute, obtuse, and right angles found within the bridge types. This could be extended to have students use a protractor to identify measurements of specific angles. If there are pictures from MnDOT of bridges with triangles used in the structure, students could determine the angles and whether they are acute or obtuse.

Other Resources

Minnesota Department of Transportation
http://wisconsindot.gov/Pages/home.aspx

Engineering a Bridge
http://www.scholastic.com/browse/lessonplan.jsp?id=1509

Lesson: Designing Bridges
https://www.teachengineering.org/view_lesson.php?url=collection/cub_/lessons/cub_brid/cub_brid_lesson02.xml

Name: ______________________________

Class: ______________________________

Date: ______________________________

Geometry of a Bridge: Data Sheet

BRIDGE NAME (Most bridges have an identifying name)	**WHERE IS IT LOCATED?** (City, State)	**KEY SHAPES IN BRIDGE DESIGN** (write down shapes and angle types you see in the image)

Tally of Shapes Seen in Bridges

SQUARE	RECTANGLE	TRIANGLE	ARCH	TRAPEZOID

Name: ______________________________

Class: ______________________________

Date: ______________________________

POPSICLE STICK BRIDGE DATA WORKSHEET

TEAM NAME (3-4) students per group	**WHAT SHAPE(S) DID YOU USE?**	**HOW MANY POPSICLE STICKS WERE USED?**	**HOW MUCH WEIGHT?** (Trial 1)	**HOW MUCH WEIGHT?** (Trial 2)	**HOW MUCH WEIGHT?** (Trial 3)

Group: ______________________

Class: ______________________

Date: ______________________

BRIDGE DESIGN SHEET

Draw your bridge design here:

Number of popsicle sticks you plan on using:

Now that your design has been completed, it is time to get to work and build your model. Work together.

Name: ______________________________________

Popsicle Bridge Worksheet

Let's test the bridge! If your engineering team is successful, your bridge model should withstand the given weight for at least 1 minute. For teams who find success with the first weight trial, they will continue with additional weight for two more trials.

1. Was your bridge successful? If not, why does your team think it failed?

   Trial 1: YES or NO

   Trial 2: YES or NO

   Trial 3: YES or NO

2. Did your team make any changes from the design process while you were actually building your bridge structure? If so, why?

3. How many popsicle sticks did you actually use in your model? Was this different from the design plan? If so, why was there a difference?

   Number in Model: ________________

   Number in Design Plan: ______________

4. Do you think that engineers have to change their original plans during the actual construction? Why might changes be made?

5. If you had a chance to improve your popsicle stick bridge, how would you change it? Why?

6. Were you inspired by any other groups as you were creating your design or during your actual constructing of the model?

7. If you had a choice to work alone or work with others on a project, which would you prefer and why?