BRIDGES

An Integrated STEM Teaching Guide

For Grades 4-8

Provided by

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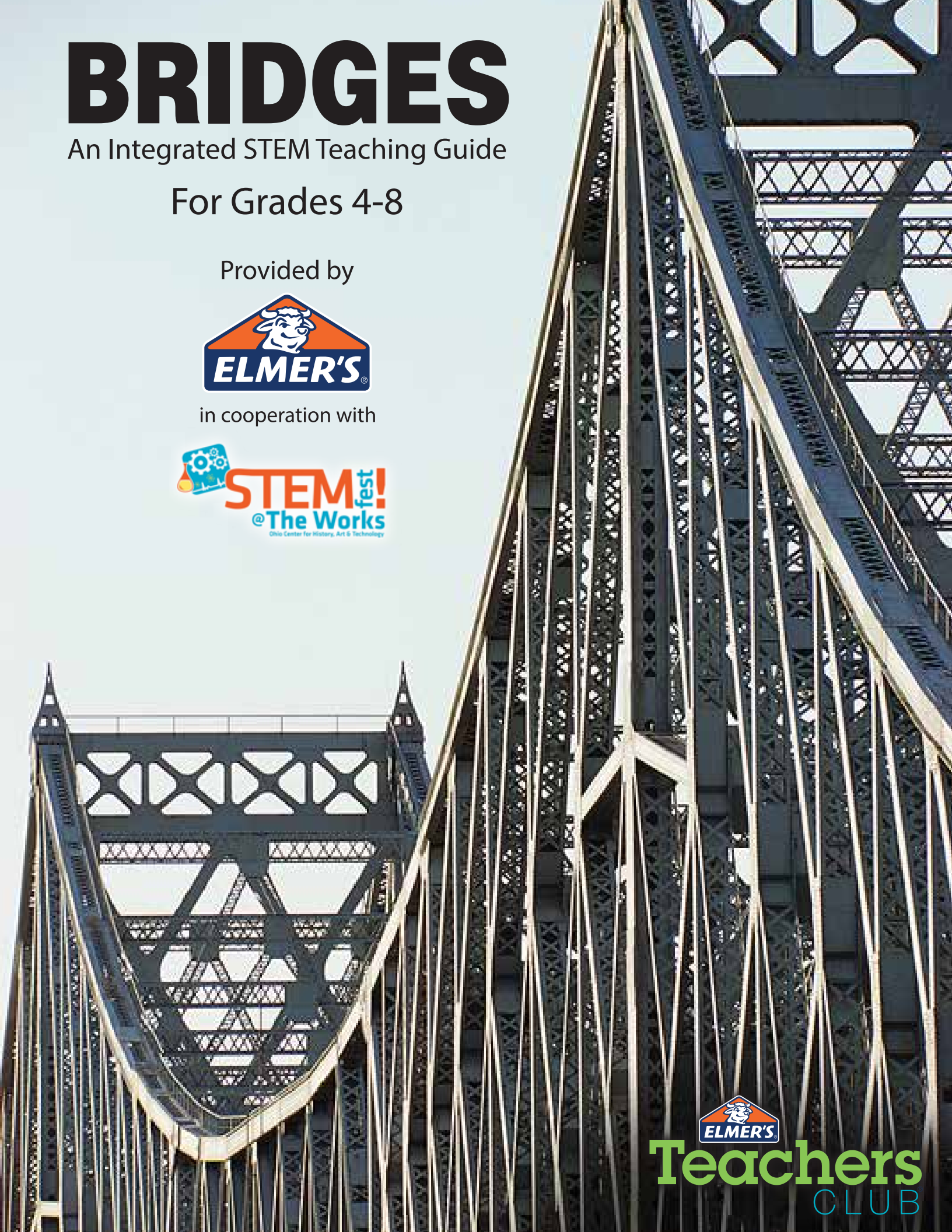

ELMER'S Teachers CLUB

Bridges: An Integrated STEM Teaching Guide

This interactive inquiry-based instructional unit is designed to teach students about different types of bridges and set the foundation for the STEM principles involved in their construction. This instructional guide combines a variety of hands-on and research-based learning experiences to identify the strengths and weaknesses of different types of bridges before students construct their own models. The activities provided in this instructional guide incorporate principles of science, history, mathematics, engineering and English/language arts for students in grades 4-8. Teachers can easily adapt the lessons and provide engaging, hands-on creative learning experiences for students in any classroom.

Table of Contents

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Academic Standards

Common Core State Standards

- CCSS.ELA-Literacy.CCRA.SL.4 Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.
- CCSS.ELA-Literacy.CCRA.SL.5 Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations.
- CCSS.ELA-Literacy.CCRA.R.10 Read and comprehend complex literary and informational texts independently and proficiently.
- CCSS.Math.Practice.MP4 Model with mathematics.
- CCSS.Math.Practice.MP5 Use appropriate tools strategically.
- CCSS.Math.Practice.MP6 Attend to precision.

Next Generation Science Standards

- 3-5.Engineering Design 3-5-ETS1-1: Define a simple design problem reflecting a need or a want that includes specific criteria for success and constraints on materials, time, or cost.
- 3-5.Engineering Design 3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- 3-5.Engineering Design 3-5-ETS1-3: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model that can be improved.
- MS.Engineering Design MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the environment that may limit possible solutions.
- MS.Engineering Design MS-ETS1-2: Evaluate competing design solutions using a systemic process to determine how well they meet the criteria and constraints of the problem.
- MS.Engineering Design MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
- MS.Engineering Design MS-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Learning Objectives

- Students will identify the main types of bridges and understand the strengths and weaknesses of each.
- Students will identify how each type of bridge is constructed to support weight.
- Students will read informational text about bridges to understand events, procedures, ideas, or concepts in a historical context.
- Students will identify how geometry affects bridge design and function.
- Students will work in teams to solve a problem.
- Students will design and construct a bridge that will support weight.
- Students will calculate the cost of the bridge they've constructed.

Background Information

Bridges have been around since the first tree fell across a stream of water providing access across. Modern day bridges are important civil engineering structures, but students should understand how they have evolved over the civilizations before us as well as the applications of art, architecture, engineering, science, and mathematics that are used to reshape our environment and improve transportation.

The design and construction of any item requires critical thinking and invaluable problem solving processes. The activities provided here include hands-on experiences, collaborative problem solving, and an integrated approach to STEM, the process of scientific investigation, and literacy skills.

List of Materials

Elmer's School Glue
Elmer's Glue-All®
Toothpicks
Small craft sticks
Rulers
Graph paper
Heavy-duty scissors or wire cutters (for cutting the sticks)
Binder clips
Spaghetti (uncooked)
Clean, empty half-gallon milk cartons
Masking tape
Weights (to measure bridge strength)

Recommended Reading and References

Pop's Bridge by Eve Bunting (fiction picture book)

The Brooklyn Bridge by Elizabeth Mann (nonfiction picture book)

Bridges: Amazing Structures to Design, Build and Test by Carol Johmann, Elizabeth Rieth, and Michael Kline

The World's Most Amazing Bridges by Michael Hurley

Building Big: Bridges by David Macaulay and Larry Klein (DVD)

Required Knowledge/Vocabulary

Students will develop an understanding for the following terms by the conclusion of the unit:

- span
- deck
- clearance
- truss bridge
- beam bridge
- suspension bridge
- arch bridge

Springboard for Learning

1. Begin by introducing the book, *Pop's Bridge* by Eve Bunting to the students. Show the cover illustration and ask students to predict what the story will be about. If students recognize the Golden Gate Bridge in the picture, ask them to share what they know about it. Using fiction picture books is a great way to set the stage for learning - even for more advanced readers. Later in the unit, you can introduce a more challenging nonfiction text, *The Brooklyn Bridge* by Elizabeth Mann.

2. After reading the story, ask students if they know of other famous bridges in the United States. Explain that the Golden Gate Bridge is a suspension bridge, but there are four main types of bridges. Write the word BATS on the board or chart paper and explain that this will help them remember that the four main types of bridges are beam, arch, suspension, and truss.

3. Challenge the students to explore each type of bridge and the design criteria that engineers consider when they are building a bridge.

Discussion Questions

- What is the purpose of a bridge?
- Which bridge do you think is the strongest?
- What factors determine which bridge is the best for a given area?
- What concerns might you have if you were building a bridge?
- What is the difference between design and function?

Vocabulary Activity: Bridge Lingo

Even though there are different types of bridges and each has unique structural components, students should understand the basic parts that are common to most. Read the book, The Brooklyn Bridge by Elizabeth Mann aloud to the students. This book provides a wealth of information about the parts and functions of bridges. Be sure to share the illustrations and diagrams and make the book available as a resource to students throughout the unit.

Provide students with a copy of Bridge Lingo (handout) and instruct them to label the diagram of the suspension bridge using the words from the word bank. Remind students that this is just one type of bridge and that arches, beams, and trusses all have different parts that are specific to each. However, every bridge has a deck, supports of some kind, foundations, and abutments.

Research Activity: Types of Bridges

Provide a copy of the Bridge Research Log for each student (handout). Explain that they will research the main types of bridges and record their findings in the log. Before they begin doing the research, remind them of the mnemonic (BATS) and invite the students to name each type of bridge shown on the handout. Depending on the ability level of your students, you may decide to let them work in small groups to complete the activity. After the students have completed their research, take some time to discuss their findings.

Hands-On Activity: Paper Bridge Challenge

Introduce the Paper Bridge Challenge to the students. Explain that they will create a model of a bridge using only two sheets of paper and Elmer's School Glue. Provide the students with a copy of the Paper Bridge Challenge (handout). Allow the students to work in small groups to explore the challenge and build a model bridge. Instruct them to determine which type of bridge would be the best bridge given the criteria. Reinforce the meaning of span and width and remind them that boats need to be able to pass below the bridge. Explain that they will test their models using two textbooks placed 20 cm apart.

Depending on the ability level of the students, you may need to provide additional guidance using the strengths and weaknesses of each bridge type that they discovered in the previous research activity. When the students have completed the challenge, give each group an opportunity to present their bridge designs with the rest of the class. Students should be able to explain the process they used to determine which type of bridge would work the best, how they constructed it, and the results of their weight load test.

Extend this activity by testing the models to see which one can support the most weight. Provide students with a third piece of paper and ask them what structural elements they might add to make their bridge support even more weight. Host a class competition to find out which bridge is the strongest.

Note: You'll need to plan for glue drying time to complete this activity. It works much better if you allow the students to construct the bridges on one day and test them the next day. Additional time may be necessary for students to modify their designs.

Research Activity: Famous Bridges

Now that the students have explored some of the characteristics of the four main types of bridges, additional research will enable them to extend that learning. This activity provides an opportunity for them to learn about other famous bridges and identify the historical significance of each.

Provide each student with a copy of Famous Bridges (handout) and access to online or print reference materials. Explain to students that they should try to find out the type of each bridge as well as the significance that each bridge has in our country's history. If time is limited, you may decide to let the students work in groups and divide the research.

Explain what is meant by "historical significance." Take a few moments to review the facts about the Golden Gate Bridge that students learned from the books, *Pop's Bridge* and *The Brooklyn Bridge.* Information about the Golden Gate Bridge is provided on the student handout as an example to guide them through the rest of the activity.

Anji Bridge is a stone arch bridge in China built in 600 A.D. Anji Bridge means "safe crossing" in Chinese.

The Forth Bridge is a beam bridge in Scotland that was initially designed to be a suspension bridge. This was the first railroad bridge made only of steel inspired by the cantilever. It took 7 years to complete and 10 times the amount of metal in the Eiffel Tower.

The Confederation Bridge in Canada is the world's longest beam bridge (8 miles long) over icy waters in the Northumberland Strait. It is known as one of Canada's top engineering achievements of the 20th century.

The Niagara Falls Bridge was the world first railroad suspension bridge. Connecting Canada to New York, this bridge brought a large influx of trade and tourism to the Niagara Falls area. It was dismantled in 1897 and replaced by the Whirlpool Rapids Bridge.

The Brooklyn Bridge is a suspension bridge designed by John Roebling (the same engineer that designed the Niagara Falls Bridge) to provide a route over the East River. The Brooklyn Bridge was the first steel and wire suspension bridge constructed.

The Francis Scott Key Bridge, also known as the Key Bridge, is one of the longest continuous truss bridges in the world. The bridge incorporates the arches into the design.

Note: *Building Big: Bridges* by David Macaulay and Larry Klein (DVD) is a great resource to use with this activity. Details of many of the bridges on the student handout are explained in the DVD with historical footage and photographs.

Hands-On Activity: Bridge Tower Challenge

When civil engineers design a bridge, they have to consider both the span and the amount of traffic that can be on the bridge at any one time to determine the weight load. Suspension bridges like the Golden Gate Bridge are designed to span long distances and hold the most weight due to their ability to distribute the load through both cables and towers.

Reinforce the key vocabulary words students will need to complete this activity. If necessary, instruct students to review the suspension bridge labeling activity they completed previously.

Explain to students that they will design and build a model of a bridge tower similar to the towers used in the Golden Gate Bridge. Their challenge is to construct a model tower that balances the longest road possible, supports the most weight possible, and doesn't shift or twist. In the real world, engineers do not have unlimited resources to build a bridge. This activity incorporates calculating costs for materials and staying within a budget.

Divide the students into small groups of 3 or 4. Provide each group with a clean, empty half-gallon milk carton, a package of uncooked spaghetti, masking tape, 2 straws and a copy of the Bridge Tower Challenge (handout). Cut the top of the carton off evenly to create a flat surface to test the span. Instruct the students to design a bridge tower that has a clearance of 9 inches high by taping the spaghetti noodles to the milk carton to serve as supports for the tower. The spaghetti can be taped to the carton, and the carton must be positioned with the open side facing up so students can measure the amount of weight it will support. Use strips of cardboard at varied lengths from 12 inches to 36 inches long to test the design that balances the longest road on top of the tower. Also, part of the challenge is to construct the most cost-effective bridge possible. Students will calculate the cost of the materials they use to construct their tower.

Note: An important aspect of this learning experience is to allow students the opportunity to test and improve their tower designs. Be sure to provide enough time for this process so that students can collaborate and modify their designs if necessary.

When all of the groups have completed their towers, host a competition to see which tower supports the most weight and span at the lowest cost. Provide time for each group to present their tower, explain their rationale for the design, and demonstrate the weight and span it will support to the class. The group that constructs the strongest tower at the lowest cost will win the challenge.

Hands-On Activity: Truss Bridge Challenge

In this activity, students will explore why trusses are used in bridges to add strength and stability. Truss bridges are constructed by connecting a framework of triangles. Trusses are a key engineering concept because they do not change when force is applied. The triangular shapes help to spread the force evenly around the three sides.

Introduce the activity by asking students if they think a triangle is sturdier or stronger than a square. Many students may initially predict that a square will be sturdier since it has more sides. Provide each student with 2 plastic drinking straws. Instruct the students to create an equilateral triangle shape with one and a square shape with the other. Use tape to secure the two ends and complete the shape. Allow students to apply force to one corner of the square and note how the shape changes into a diamond shape. Apply force to one corner of the triangle and discuss how the shape doesn't change as easily because the three sides distribute the force more evenly.

Divide the students into small groups of 3 or 4. Provide each group with the following materials:
Graph paper to design their bridge
Craft sticks (100 sticks per group)
Heavy-duty scissors or wire cutters for cutting the craft sticks
Elmer's Glue-All
Binder clips
Truss Bridge Challenge (handout)

Show the students a sample bridge or pictures of truss bridges. Point out that the sides of the bridge are made up of many triangles that add stability. Instruct the students to follow the instructions on the handout to construct their own truss bridge. Remind them that engineers must stay within a budget when building bridges.

You may extend this lesson with more advanced students to explore the forces of compression and tension.

Competition: Toothpick Bridge Challenge

The procedure and guidelines for this activity have been provided by The Works® Ohio Center for History, Art & Technology. Toothpick Bridge Challenge rules and specifications sponsored by: Licking County Engineers Office, Jobes Henderson and Associates and Ohio University Civil Engineering.
For more information visit www.attheworks.org.

This culminating activity provides students with an opportunity to demonstrate their learning and understanding of different bridge types, geometric principles and engineering concepts of bridges. The goal of the competition is for students to design the most efficient, economical, and aesthetic bridge as an overland route over a waterway. Students can design any type of bridge they choose,

however the only materials they can use to construct it are round toothpicks (a maximum of 1000) and Elmer's Glue-All.

Provide the Toothpick Bridge Competition (handout) to students to guide them through the construction of their bridges. Explain the bridge specifications with them and the criteria by which the bridges will be judged. Remind students that you encourage parental participation, however each student will be expected to present his/her bridge at the competition and describe the rationale for the design.

Share and discuss the Toothpick Bridge Judging Rubric (handout) with the students so that the expectations are clearly communicated.

Helpful hints for a successful classroom or school competition:

- The bridge support platform (see Toothpick Bridge Challenge handout) can be replaced with two strong tables and a two little pieces of sandpaper.
- The loading block can easily be created or can be replaced with a small chain and carabineer clip that can be clipped through the chain and onto the bucket handle.
- You can use sand or weight in the bucket to test the load; be sure to place a tablecloth under the tables.
- Younger students may be more successful if they plan their bridge construction on graph paper first. Then, place a piece of waxed paper over the graph paper so that they can construct right over their blueprint plans.

Home-School Connection

There is an abundance of research that demonstrates the positive affects of parental involvement on student achievement and social and emotional growth. The most accurate predictor of a student's achievement in school is not income or social status but how the family supports learning at home. With a bit of guidance and clear expectations, you can help parents foster a home environment that encourages learning and creativity.

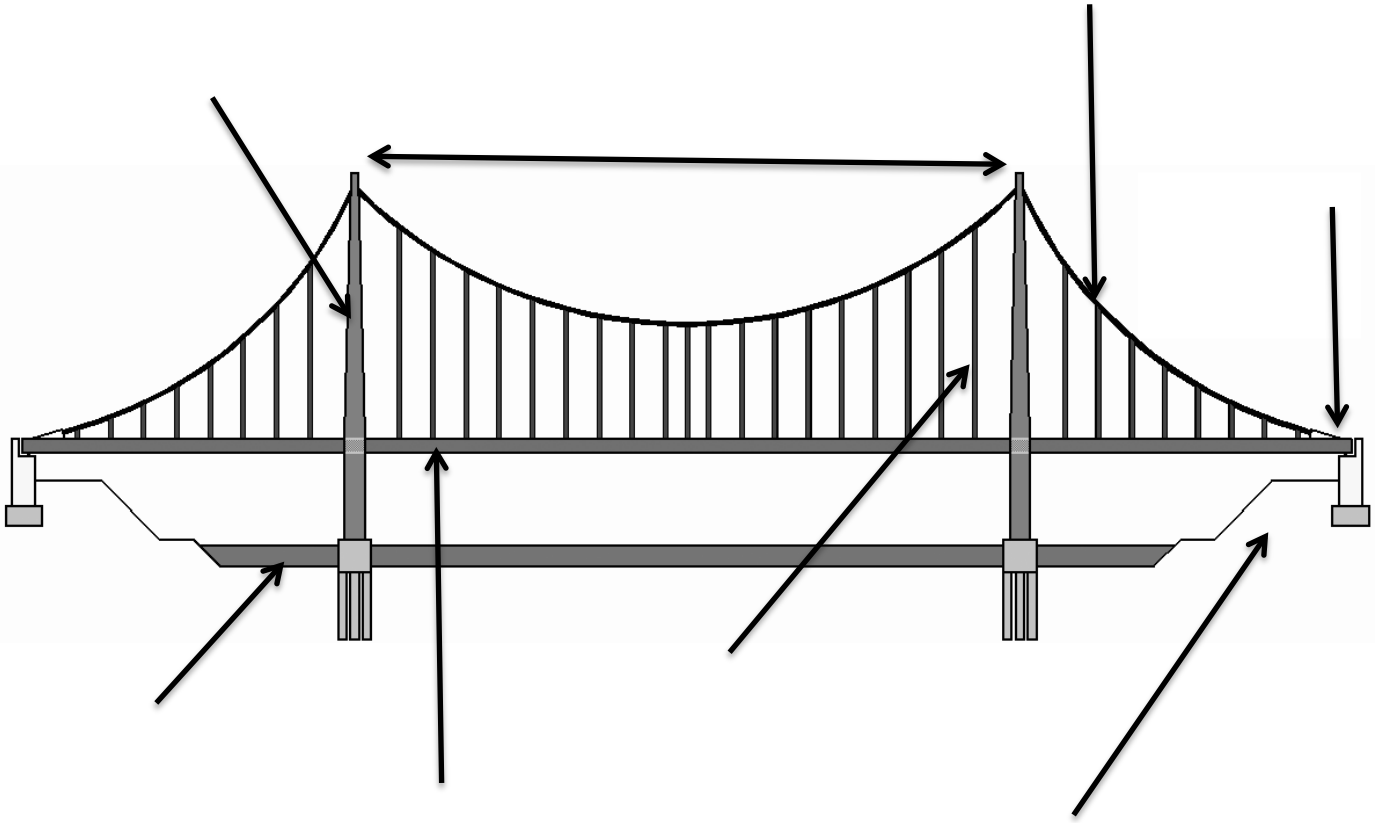
Provide the Home-School Connection Parent Letter for students to take home with the Toothpick Bridge Competition Guidelines (handouts). Communicate to parents what their children have learned and enable them to apply the science math, and engineering concepts even further in an at-home activity that students will present during the competition.

STUDENT ACTIVITY PAGES AND HANDOUTS

Name_____

Bridge Lingo

Bridges are everywhere and serve many different purposes. Without them, we would not be able to travel over water of any kind. They can be as simple as a log across a small creek and as complex as the Golden Gate Bridge that spans 1.7 miles from abutment to abutment. Bridges may look very different, but their structural parts are similar. Use the words from the word bank to label the bridge diagram below.

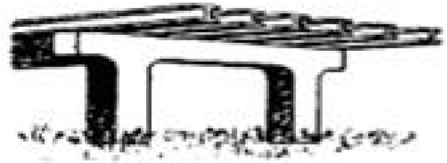


Word Bank		
span	cable	tower
deck	hanger	anchor
abutment	foundation	

Bridge Research Log

Name_____

Research the four main types of bridges and record your findings in the chart.

Type of Bridge	Description of Bridge	Strengths and Weaknesses
		
		
		
		

Name_____

Paper Bridge Challenge

The Problem: The Mohawk River is a popular waterway for many people who enjoy boating, skiing, and kayaking. In addition, several barges use this waterway to transport goods. The river separates the cities of Angel Falls and Hogan. Currently, there is only one bridge that connects the two cities. Since that is the only way for people to travel by car back and forth, there are frequent traffic delays on and near the bridge. The officials in each city have determined that a second bridge would make it easier for residents to travel back and forth and reduce the amount of traffic on the first bridge.

The Challenge: A representative from the city has contacted you to design a model of a bridge that would help reduce the car traffic and still enable the use of the river for boats and barges.

The Criteria: Your model bridge must have a span of at least 20 cm, a width of at least 3 in, and support the weight of 100 pennies. Remember that it should be designed to allow boats to pass below the bridge.

The Materials: You may use 2 sheets of plain white paper and Elmer's School Glue to construct a bridge. You may cut, fold, or glue the paper any way you wish as long as you meet the criteria. You must test your model to make sure it supports the weight of 100 pennies by placing two textbooks 20 cm apart, the bridge on top of the books, and the pennies on the bridge.

Brainstorm, Design and Build!

What type of bridge do you think would be the best for this challenge? Sketch your bridge design on a piece of paper and identify some ways that you might make it strong enough to support the necessary weight. Build your model and test it to see if you will get the job!

Name_____

Famous Bridges

There are many bridges that have been built over the years that have shaped civilizations and have historical significance. Research the bridges in the table below and see how many facts you can find about each.

Bridge	Type	Historical significance
Golden Gate Bridge	Suspension	Enabled people to cross the San Francisco Bay; was known as the "impossible bridge"
Anji Bridge		
Forth Bridge		
Confederation Bridge		
Niagara Falls Bridge		
Brooklyn Bridge		
Francis Scott Key Bridge		

Name_____

Bridge Tower Challenge

The Problem: In a suspension bridge, the middle supports are called towers. Long steel cables are strung over the towers and secured to anchors at both ends of the bridge. Your city has decided to construct a suspension bridge across a large lake that is almost one mile wide. They must construct a bridge that will span the width of the lake, support the weight of the cars that will travel across the bridge, and not shift or twist.

The Challenge: A representative from the city has contacted you to design a model of a bridge tower that will support the length and load of this suspension bridge.

The Materials: You will use spaghetti noodles to represent the beams that will be secured to the foundation of the bridge, a milk carton to represent the top of the tower where the cable will be attached, and masking tape. You may use no more than 100 spaghetti noodles and 2 straws. You may only use the tape to secure the spaghetti noodles to the can.

The Cost: Your bridge tower must be cost efficient to build. You have a budge of $70,000 for each tower. Using the cost of materials below, calculate the cost of your tower.

Beams (spaghetti noodles) = $500 each
Support beams (straws) = $1,500 each
Securing rods (masking tape) = $300/inch
Tower (milk carton) = $10,000

Brainstorm, Design and Build!

What design do you think would be the best for this challenge? Sketch your bridge design on a piece of paper and identify some ways that you might make it strong enough to support the most weight and the longest road possible within your budget. Build your model and test it to see if you will get the job!

Name_____

Bridge Tower Challenge

Group	Span	Weight	Cost

Which team will get the contract? Why do you think this design is the best?

Name_____

Truss Bridge Challenge

The Problem: The National Railroad Company has added a new fleet of trains to transport goods across the country. A narrow river runs through a deep valley in one section of the railroad plan. A new bridge must be constructed to accommodate the railroad addition. The bridge must be stable enough to keep the train level as it crosses the valley.

The Challenge: A representative from the city has contacted you to design a model of a truss bridge that will be stable enough to keep the train level as it crosses the valley.

The Materials: You can only use craft sticks and Elmer's Glue-All to construct the bridge. You may use binder clips to hold the craft sticks in place until the glue dries, but they must not be included in the final bridge design.

The Cost: Your truss bridge must be cost-efficient to build. You have a budge of $100,000 to construct it. Using the cost of materials below, calculate the cost of your bridge.

Beams (craft sticks)	= $1000 each
Iron joints (glue)	= $5000/bottle

Brainstorm, Design and Build!

What design do you think would be the best for this challenge? Sketch your bridge design on a piece of paper and identify some ways that you might make it stable enough and strong enough to support the train while staying within your budget. Build your model and test it to see if you will get the job!

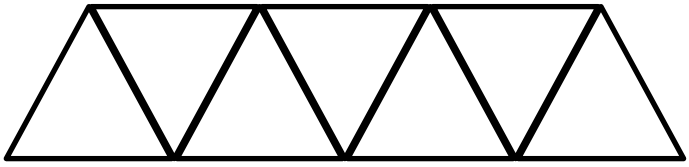
Name_____

Truss Bridge Challenge

With a few craft sticks, some Elmer's Glue-All, and a lot of patience you can build an amazing truss bridge. Here are some tips to get you started.

1. Begin by building the side trusses. Start by building the top, bottom and sides in the shape of an isosceles trapezoid. Use four craft sticks on the bottom, three on the top and one on each side. Make sure the top and bottom are straight, glue them side pieces in place, and let them dry.

2. Next, add a stick to each joint to create the trusses inside.



3. Lean the side pieces against thick heavy books so that you can add the top of the bridge. Construct the top of the bridge by connecting the sides with a craft stick at each joint.

4. Decide the best way to construct the top and the bottom of the bridge and attach the sides. Remember, you must stay under budget and your bridge must be sturdy enough to support the train and keep it level.

Home-School Connection

Dear Parent or Guardian,

The past few weeks, we have been studying bridges and the scientific principles involved in their design and construction. We have learned about some famous bridges that have had a significant impact on our country's economy, transportation system, and engineering advances. I encourage you to have a conversation with your child and give him/her an opportunity to share this new learning with you.

As a culminating activity for this learning experience, a Toothpick Bridge Competition is scheduled for _____ . This is an exciting event that will provide students with an opportunity to demonstrate their learning and understanding of different bridge types, geometric principles and engineering concepts of bridges. The goal of the competition is for students to design the most efficient, economical, and aesthetic bridge as an overland route over a waterway. Students can design any type of bridge they choose, however the only materials they can use to construct it are toothpicks and Elmer's Glue-All®.

Each student will be judged on both the bridge and the presentation that includes the reasons for why the bridge design was chosen over another, important research of bridge designs, strength of shapes and the forces that act on structures, bridge cost information, cost effectiveness predictions, strength ratio data, graphs and pertinent career information.

A separate information sheet provides all of the details about the Toothpick Bridge Competition specifications, guidelines, and evaluation. Please take some time to review this information with your child so that you can plan the research and construction effectively.

There is an abundance of research that demonstrates the positive affects of parental involvement on student achievement and social and emotional growth. The most accurate predictor of a student's achievement in school is not income or social status but how the family supports learning at home. I hope you will embrace this opportunity and enjoy working with your child on this valuable learning experience.

Thank you for your continued support.

Sincerely,

Toothpick Bridge Challenge

Specifications, Guidelines, and Evaluation

The Challenge:

Your challenge is to construct a bridge that will serve as an overland route over a waterway. The goal is to design and create the most efficient, economical and aesthetic bridge possible using only toothpicks and glue.

The Criteria:

The structural efficiency is equal to the weight supported divided by the weight of the bridge. The aesthetics of the bridge will be determined through visual appeal, uniqueness, neatness and symmetry. The bridge will also be judged on cost effectiveness.

Points will be awarded for presentation and presentation materials. PowerPoint presentations should be no longer than ten (10) minutes in length and include reasons for why your particular bridge design was chosen over another, your research into bridge designs, strength of shapes and the forces that act on structures, bridge cost information, cost effectiveness predictions, strength ratio data, graphs and pertinent career information.

The Specifications:

- **Span**: The bridge must have a ***minimum*** clear span of 12 inches in length, and rest on abutments on either side of the river. The abutments are to be part of the bridge. (See Bridge Support Platform Photo)
- **Vehicle Deck**: The bridge deck must be at least 1.5 inches wide. This will be tested with a matchbox car. The deck must be solid so that the car can travel the length of the bridge. The loading block will also be placed on the deck.
- **Bridge Width:** The maximum width of the bridge is 2.5 inches.
- **Boat Clearance:** The bridge must be more than 2 inches above the water. A 2 inch high boat must pass unobstructed underneath the bridge.
- **Bridge Height**: The maximum height of the bridge is 8 inches from the river surface.
- **Loading Connection**: The bridge must be able to accommodate the loading block (1.5 inches by 2 inches) at the midpoint of the deck. The loading block will be placed on the vehicle deck of the bridge (the same place the matchbox car travels). ***A hole in the center of the bridge MUST allow for a 1/4 inch rod to pass through the vehicle deck.*** (See the Loading Block Connection Photo.)

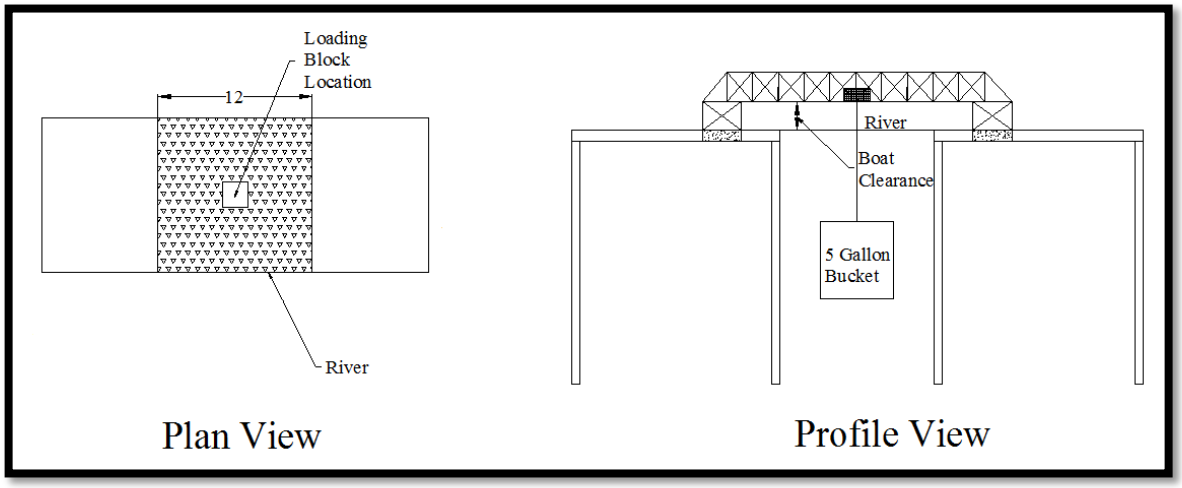


Figure 1 – Bridge Layout

Figure 2 - Bridge Support Platform

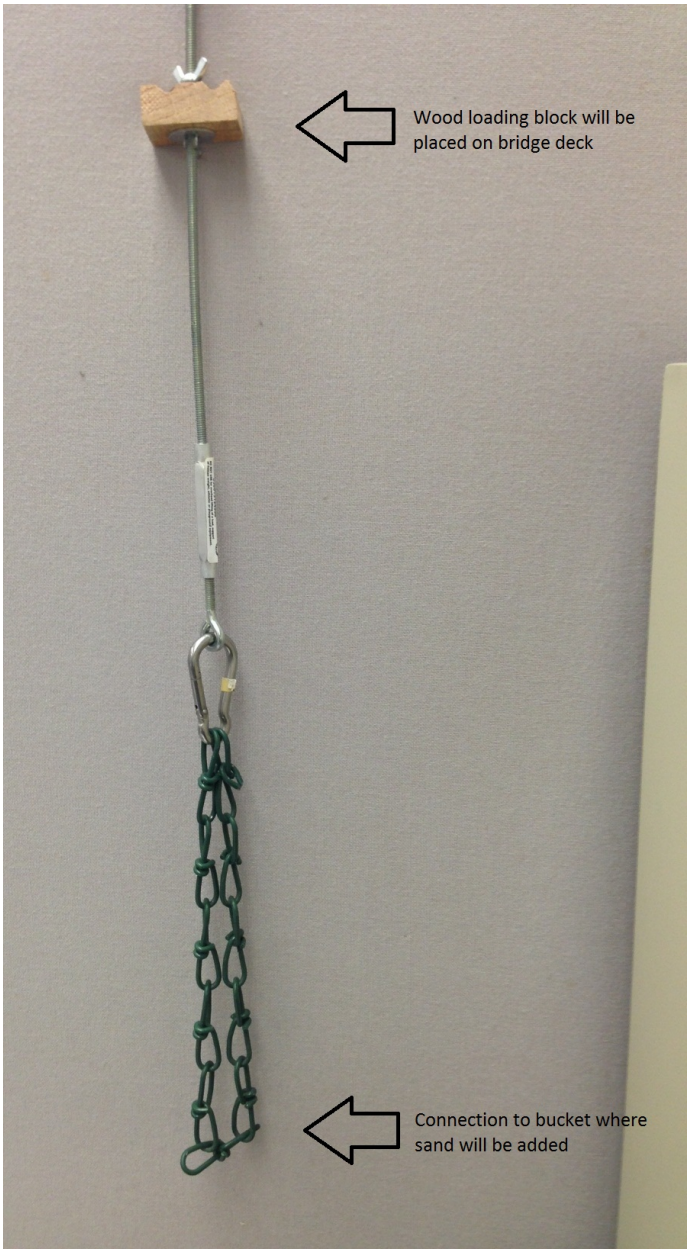


Figure 3 - Loading Block Connection

Material Specifications:

- Round uncoated toothpicks (maximum 1000 toothpicks)
- Elmer's white glue. ***Epoxy, wood glue, hot glue, paint and super glues are not permitted.***
- Do not coat the bridge with any material (paint, stain or glue).
- Any bridge not meeting the material specifications will be penalized.

Strength Ratio Predictions:

- Make strength ratio predictions using the weight of your bridge and the following weights, 10lbs, 20lbs, 30lbs, 40lbs, 50lbs, 60lbs and 70lbs.
- Strength ratio is determined by dividing the weight of the bridge by weight held.
- Show your results graphically. Be prepared to share your results with the judges.

Bridge Cost:
Calculate the cost of your bridge by using the following

Cost Specifications:

$50 for 10 Toothpicks

$50 for 1oz of Glue

Cost Effectiveness Predictions:

- Make cost effectiveness ratio predictions using the total cost of your bridge and the following weights, 10lbs, 20lbs, 30lbs, 40lbs, 50lbs, 60lbs and 70lbs.
- Cost effectiveness is determined by dividing the total cost of the bridge by weight held.
- Show your results graphically. Be prepared to share your results with the judges.

Testing Procedures:

1. All bridges will be weighed and measured for compliance with the bridge specifications. Bridges that are completed but do not meet the bridge specifications can be penalized up to **ten** points.
2. The loading block and testing apparatus will be provided and may not be altered.
3. During the testing of the bridge, the bridge will be placed in the center of the testing apparatus.
4. The load will be applied to a 1.5 inches wide by 2 inches long by 1 inch

high loading block resting midway in the river. A hole in the center of the bridge must allow a 1/4 inch rod to pass through.

5. Pulling force will be applied straight down by a pulling cable until the structure exceeds the acceptable deflection (0.75 inches at the center) or until obvious structural collapse. ***NOTE* The loading process has been updated, but it does not change how you should build your bridge. You still need to allow for the loading block to rest on the vehicle deck of your bridge and a ¼ hole in the center of the bridge.**

The total load incorporates the total mass of the loading apparatus, bucket and sand.

The Competition:

On the day of the competition your bridge will be examined for appearance, adherence to bridge specifications, and strength.

Your bridge will be evaluated on each of the following categories:

1. Aesthetics (5 points)
2. Presentation (15 points)
    a. Presentation must include the total cost for your project, cost effectiveness predictions and graph, strength ratio data and strength ratio graph.
    b. Share the process used to determine the bridge design you created.
    c. Refer to the career titles explored in your research when you present your bridge.
3. Bridge Specifications (10 points)
    a. Clear Span (needs to be at least 12 inches)
    b. Vehicle Deck (needs to be at least 1.5 inches wide for matchbox car)
    c. Bridge Width (maximum width is 2.5 inches wide)
    d. Boat Clearance (at least 2 inches clear distance from table top)
    e. Bridge Height (maximum of 8 inches tall)
    f. Loading Connection (accommodates the loading block on top of vehicle deck)
4. Strength Points (10 points)
5. Cost Effectiveness Points (10points)
6. In the event of a tie the lightest bridge will be the winner.

*This activity is provided by The Works® Ohio Center for History, Art & Technology. Toothpick Bridge Challenge rules and specifications sponsored by: Licking County Engineers Office, Jobes Henderson and Associates and Ohio University Civil Engineering.)

Toothpick Bridge 2014

Criteria:					Score
Presentation (15 points)	Preparation minimal; no eye contact, disorganized (2 points)	Presentation is somewhat organized and contains few of the required elements. (6 points)	Presentation is mostly organized, and includes most of the required elements (11 points)	Enthusiastic, well – prepared, organized, all team participates, includes design process, strength graph, bridge terminology, and total cost. (15 points)	
Appearance (5 points)	Bridge is messy, not clean, with extra glue and/or toothpicks (0 points)	Bridge has some appealing qualities, but is mostly messy and very clean (1 point)	Bridge has many appealing visual qualities, but still has one or two messy areas (3 points)	Bridge is neat and clean, no extra glue, toothpicks out of place (5 points)	
Bridge criteria (10 points)					
Clear span	Does not meet criteria (0 points)			Meets criteria (1 point)	
Vehicle Deck	Does not meet criteria (0 points)			Meets criteria (1 point)	
Bridge Width	Does not meet criteria (0 points)			Meets criteria (1 point)	
Boat Clearance	Does not meet criteria (0 points)			Meets criteria (1 point)	
Bridge Height	Does not meet criteria (0 points)			Meets criteria (1 point)	
Loading connection	Does not meet criteria (0 points)			Meets criteria (5 points)	
Strength Points (10 points) Given as [(team ratio/maximum ratio) *10]					
Team ratio:		Max ratio:		Points:	
Cost Effectiveness (10 points) (cost of bridge/weight held) Given as [(team cost effectiveness/maximum cost effectiveness)*10]					

STEMfest! Competition Photos

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