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Bridges Built on a Firm Foundation

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Bridges. Some are small and insignificant, while others are quite extraordinary. You may even feel that some should come under the category of "Wonders of the World." However you may feel about them, all bridges are made for specific reasons. Convenience and money are reasons that top the charts.

What is a bridge? A bridge is a structure used by people and vehicles to cross-areas that are obstacles to travel. Engineers build bridges over lakes, rivers, canyons, and dangerous highways and railroad tracks. Without bridges, people would need boats to cross waterways and would have to travel around such obstacles as canyons and ravines.

Bridges range in length from a few feet or meters to several miles or kilometers. A bridge must be strong enough to support its own weight as well as the weight of the people and vehicles that use it. The structure also must resist various natural occurrences, including earthquakes, strong winds, and changes in temperature.

Most modern bridges have concrete, steel, or wood framework and an asphalt or concrete roadway. The roadway is the part of a bridge on which people and vehicles travel.

The majority of bridges are held up by at least two supports set in the ground. The distance between two adjacent supports is called a span of a bridge. The supports at each end of a bridge are called abutments, and the supports that stand between the abutments are called piers. The total length of the bridge is the distance between the abutments. Most short bridges are supported only by abutments and are known as single-span bridges. Bridges that have one or more piers in addition to the abutments are called multi-span bridges. Most long bridges are multi span bridges. The main span is the longest span of a multi span bridge.

The unit is set up according to the following outline:

-Types of bridges -Focus -Objectives -Background History of the bridge
-Vocabulary -Lesson Plan -Activity/Field Trip
-Reading lists

For further information you can go to the library and surf the net, get bridge construction videos, and more books.

Kinds of bridges

There are seven main kinds of bridges (1) girder bridges, (2) truss bridges, (3) arch bridges, (4) cantilever bridges, (5) suspension bridges, (6) cable-stayed bridges, and (7) drawbridges. Only the three that will make up our final game will be defined in this unit, cantilever, drawbridge, and arch.

The types of bridges vary in total length, the length of their spans, and the weight they can support. Before deciding which kind to build at a particular place, engineers determine the length of the structure and of each span. They also must consider the maximum load that the bridge will carry and the materials available to construct the bridge.

Cantilever bridge

Cantilever bridges consist of two independent beams called cantilevers that extend from opposite banks of a waterway. The two cantilevers are joined together above the middle of the waterway by a beam, girder, or truss. Cantilever bridges may have spans as long as about 1,800 feet.

Each cantilever has two sections, an anchor arm and a cantilever arm. The anchor extends between an abutment and a pier. The pier supports one end of the cantilever, and the other end extends freely over the waterway. The free ends of the two cantilevers are joined together by a suspended span.

Most cantilever bridges have two anchor spans and one center span. Each anchor span consists of an anchor arm. The suspended span and the two cantilever arms make up the center span. Many cantilever bridges have truss framework. Most bridges of the cantilever type are made of steel or prestressed concrete.

Examples of this type of bridge are Commodore John Barry - Delaware River, Chester, PA. and Bridgeport, NJ. and Osaka Port - Osaka Bay, Japan

Drawbridge

Drawbridges have a roadway that is moved entirely or partially to provide enough clearance for large ships to pass. There are three types of drawbridges, bascule bridges, lift bridges, and swing bridges. A bascule bridge tilts upward to open. Some bascule bridges open at one end, and others open in the middle. A lift bridge has a roadway that extends between two towers. The roadway rises between the towers, and ships pass underneath. A swing bridge is mounted on a central pier. The bridge swings sideways to enable ships to pass. An example of the lift type of bridge is the Tomlinson Bridge

Arch bridges

Arch bridges are structures in which each span forms an arch. The spans range up to about 1,700 feet (518 meters) long. The arch bridge is one of the oldest types of bridges. Early arches consisted of large stone blocks wedged together to form an arch. Today, the majority of arch bridges that have short spans are made of concrete or wood. Arch bridges with long spans are built of concrete or steel.

Engineers must design arch bridges so that the sides of the arch do not spread apart and collapse the bridge. The roadway of some arch bridges lies on top of the arch and is supported by vertical columns called spandrel columns. These columns transfer the load of the roadway to the arch, which bears the weight of the bridge. The roadway of a tied arch bridge is below the curve of the arch. Girders or other types of beams that hang from the arch support the roadway. The girders or beams also connect to the ends of the arch to support the thrust of the bridge.

Examples of this type of bridge are New River Gorge - New River, near Fayetteville, W. Va., Eads - Mississippi River, St. Louis, MO.

Focus

In this unit we will take a look at four specific large bridges, and a few small local bridges. As we read about and observe these bridges emphasis will be made on why they were made, how they were made, and what made them a success or failure. The large bridges are The Royal Gorge Bridge in Colorado, the Lake Pontchartrain Causeway in Louisiana, the London Bridge in London, England, and the Quinnipiac Bridge in New Haven, Connecticut. The smaller bridges are in the area surrounding the school the students attend. Be sure to find some your area.

Students from grades four to six will enjoy this unit. There will be three lessons and activities and entire unit should take about two months.

Objectives

There are four main objectives in this unit. The first will be to understand causes and effects, then how they relate to the assembling of bridges. The second will be to compare and contrast the specific bridges. The third will be to identify the main parts of lift, cantilever, and arch bridges and to tie in the vocabulary terms connected with them. The fourth will be to design lift, cantilever, and arch bridges, from stencils, that they can be assembled permanently. They will be used as the main objects in the "Assembly" game. The students will develop the rules for this game, plus possible improvements in the stencils.

Background

Tell the students that we will be investigating "bridges." Ask the students do they know of any famous bridges. Remind them of the song "London Bridge is falling down," and that thinking about bridges they know about will help them understand this investigation of bridges. Encourage your students to work with a partner. Invite them to walk with you to a local bridge. Before you leave have them make a K-W-L Chart. A K-W-L chart is a way of organizing information. It is usually made up of three (3) wide columns. At the top of the first column is a K that stands for what you KNOW about a subject. The middle column would have a W at the top of it that stands for what you WANT to know about a subject. At the top of the last column would be an L that stands for what you LEARN as a result of your investigations. Have them write everything they know about bridges, then what they want to know about bridges. The purpose for going to this bridge and completing the readings is to help them focus on the information they want to know. Have the students write everything they observe in connection with the construction of this bridge. At the end of the marking period they should be able to fill in the L, what they have learned from this unit.

Vocabulary list

1-bridge - a structure used by people and vehicles to cross areas that are obstacles to travel.
2-truss bridges-supported by frameworks called trusses. The parts of the trusses are arranged in the form of triangles.
3-load - a mass or weight that is lifted or supported
4-arch bridges - structures in which each span forms an arch.
5-suspension bridges -have a roadway that hangs from steel cables that are supported by two high towers.
6-span - The distance between two adjacent supports
7-compression - pressed together or condensed
8-cantilever - a structure that extends outward from a support
9-vertical lift bridges - the entire bridge span lifts up
11-abutments - supports at each end of a bridge
12-tension - the force that pulls an object
13-pier - a support for the spans of bridges
14-voissoir - a wedge-shaped brick or stone used to build arches in bridges
15-keystone-the brick at the top center of arch bridges

Vocabulary Review

Which word means pressed together? Which bridge has a roadway that hangs from steel cables that are supported by two high towers?

Which word means the distance between two adjacent supports?

Which word means a structure used by people and vehicles to cross areas that are obstacles to travel?

Which bridge has triangles to form part of its framework?

Have the students complete the web below after reading about the different types of the bridges.

Use the word Bridges in the center of a WEB. Complete the web.

BRIDGES

Example: Bridges - arch - abutments, formwork, voissoir, keystone

Bridges - etc.

History

The Royal Gorge Bridge

Long ago, two railroad companies had a fight about a big ditch in the Rocky Mountains. The big ditch is in Colorado, and its name is the Royal Gorge.

It used to be that the only way to get to the silver mines near the top of the mountains was through the Royal Gorge. So the railroad companies began to fight to see which one would build its tracks through the gorge. They had quite a problem. The gorge is almost a quarter of a mile deep and the bottom is so narrow in some places that there seemed to be no room for anything but the river running through the gorge.

One company started building railroad tracks in the middle of the gorge. All the men and tools had to be lowered over the sides with ropes. Then the other company blockaded one end of the gorge. Both companies built forts and hired many cowboys and gunslingers.

During the day, the railroad crews worked to lay the tracks. At night, they rolled boulders down the sides of the gorge to smash each other's tracks. They dumped each other's tools in the river. They even used dynamite to wreck each other's work.

Finally, the owners of the two railroad companies met and talked things over. And one company agreed to sell its tracks so that the railroad could be finished.

If you ever visit Royal Gorge, you can get a good look at the railroad from the Royal Gorge Bridge. The Royal Gorge Bridge hangs across the top of the gorge and is the highest suspension bridge in the world, 1,053 feet above the Arkansas River.

Think About It

The convenience of this bridge may be one thing, but the fear it may cause in those who approach it is another thing. Provide a picture of this bridge. It would be so interesting to the students. There are many that have a fear of heights (acrophobia). Those with the fear of crossing bridges (gephyrophobia) would probably not be able to see the other side. How could you get them to the other side?

Lake Pontchartrain Causeway

There is a highway in Louisiana that you can ride for 24 miles and see nothing but water on both sides. It goes right across the middle of Lake Pontchartrain, the largest lake in Louisiana. Called the Lake Pontchartrain Causeway, it is the longest over water highway in the world. The state of Louisiana built the causeway so that people would not have to drive all the way around this big lake.

Think About It

Be sure to have a picture of this bridge to show the students. They will love it, especially because they probably won't be able to see both ends in one picture. Those who suffer from the fear of water (aquaphobia) will have a problem travel on its roadway because there is a point where they would see only water on both sides for miles. What adjustments could be made by you to help this person?

London Bridge

"London Bridge is falling down, falling down, falling down

London Bridge is falling down, my fair lady."

The London Bridge that was forever "falling down" in the nursery rhyme was built of stone. It was built across the River Thames in London and lasted for more than 600 years.

During those years, the bridge suffered many accidents. Ships crashed into it. The weight of traffic made it crack and sink a little. The pounding river loosened it. And it had to be repaired again and again. Some of the money for the repairs came from rent paid by people with shops on the bridge. The repairs cost so much that the people of London decided to tear it down and build another London Bridge of a strong rock called granite. But in time, it too, began to crack and sink a little. So again, the people decided to take down that bridge and build a new London Bridge made of concrete.

The granite bridge was taken apart piece by piece and shipped to the United States to be put back together again across an artificial lake in Arizona.

Think About It

Which bridge, that you have seen, should be redone? Where is it located? How would you redo it?

Making Connections

What are some of the things bridge builders must consider before building a bridge?

1. The number of vehicle or pedestrians that will use the bridge
2. The width and depth of the water, if there is water
3. The texture of the surrounding land, marshy, rocky, sandy
4. The type of bridge
5. The materials for the bridge
6. The temperature and weather conditions where the bridge will be built

Use one piece of copy paper and one piece of construction paper. Place each across two books. Can each hold an empty cup? What could you do to the papers to make them stronger? Do it? Can it support the cup now? Arrange the papers one more time, even combine them. Any improvement? Think about your bridge materials!

Take a cup fill it with sand, then drop a marble from about 6"-12" into the cup. What happened? Fill the cup with sand and a little water. Drop the marble again? What happened? Think about your foundation!

Cause and Effect -a pattern of text organization

This pattern of text organization answers the questions "What is the cause of ...?" and "What are the effects of ...?"

The following selection illustrates the cause-and-effect pattern. The outline at the end of the passage depicts the cause-and effect relationships within the discourse.

As Joland was walking pass the door, peeling the banana, he thought about how uneventful the day had been so far. Then suddenly the door opened quickly. It hit Joland from behind and he hit the floor, face first. The

banana flew over and landed into the goldfish tank. The peel landed on the floor. As Joland tried to get up slowly he slid on the yellow banana peel and bumped into the 29-gallon fish tank stand. It rolled loudly across the dimly lit room before crashing into the wall. The warm water and fish splattered everywhere so Joland was unable to leave the room until he squishing crawled out of the room on all fours. He felt something jumping around in his pants leg, which he immediately shook wildly in the air. Out flew a struggling goldfish that eventually died.

A cause-and-effect outline is as follows

Cause Effect

Door opened quickly hitting Joland from behind, then

Dropped the banana peel slipped on banana peel, then

Bumped into fish tank stand it rolled across the floor, then

Crashed into the wall warm water and fish splattered, then

Water every where Joland had to crawl out on all fours

Something jumping in pants leg he shook his legs wildly in the air

Out flew struggling goldfish then it eventually died

Student activities

1. To provide practice for your students in recognizing this form of discourse, ask them to answer the test questions on cause-and-effect patterns mentioned earlier.

2. Present them with a partially completed outline for the passage and ask them to fill in the blanks.

3. After they are comfortable with this style of text organization, ask them to generate their own outlines and diagrams of the passages about the different types of bridges. Encourage the students to use the vocabulary words in their outlines as often as possible.

Lesson 1

Cause and Effect

Purpose: To identify the cause and effect

To solve the problem of getting from one location to another

Materials: Toothpicks, twigs, yarn, string, glue, paper straws, and rocks

Time: 1 hour Class Size: Up to 26 (working in pairs)

Problem

The following selection illustrates the cause-and-effect pattern. The outline at the end of the passage depicts the cause-and effect relationships within the discourse.

_____ (A student's name) just received a new $100.00 bill. The giver told him that if she shared equal amounts of it with 9 other people not in her household she would receive (10) $100.00 bills. But there is a catch. He/She lived on an island four miles from the nearest body of land. A brother and sister who would not be returning to the island for five more days were using the only boat they had. According to the letter he/she had to complete the task of sharing the money in two (2) days. He/She tried to swim the distance, but got tired and swam back. He/She tried to call to the mainland, but the lines were dead due to the recent tropical storm. He/She thought to put (9) separate $10.00 bills into (10) bottles and launch them towards the mainland, but there would be no proof of who received the money if anyone did or it might all go to the same person. As _____ (student's name) look around the island and in the house he/she noticed some useful items and came up with an idea. How about creating a bridge to reach from the island to the mainland? Some of the items collected were twigs, toothpicks, string, yarn, glue paper straw, rocks, and paper.

Challenge

The challenge to you is to use any combination of the same or similar materials and build a model of the type of bridge _____ (student's name) could build so that he or she can acquire the money. The model has to be at least three (3) feet long, 3-4 inches wide, and hold at least ½ pound. I'm sure there is a little reward in it for you too!

Cause and Effect Outline

Complete the cause and effect outline based on the story above and add to it your experiences while building the bridge.

CAUSE EFFECT

_____

_____

Conclusion: How did your bridge hold up? What made it successful or not successful?

Compare and Contrast - a pattern of text organization

By determining how things are alike and how they are different, comparison-contrast discourse goes beyond simple descriptions to present relationships between and among topics. Text patterns of this sort provide answers to the questions "How are ____ and ____ alike?" "How are ___ and ___ different?", and "How are these things related to each other or to another factor?"

The following passage presents a comparison-contrast format for a discussion about one brand of bowling ball versus another. The outline presented after the passage categorizes in a systematic way the details of the written discourse.

Hammer vs. Champion

I went to the bowling pro shop to buy a new bowling ball. There were two name brand balls I liked, Hammer and Champion, but I had only enough money for one. They both cost about the same price. Both balls had shiny surfaces, but the Hammer was blue with 4 dull light blue spots on it and the Champion was purple. The pro shop owner assured me that both balls would give me the perfect hook shot I've been seeking. I decided to test each brand for comfort and control. I bowled one complete game with the Hammer, and another complete game using the Champion. The Champion gave me a nice, strong hook, but I was able to control the Hammer better. My score with the Champion was 176, but my score with the Hammer was 215. Can you guess which ball went home with me that day?

A comparison-contrast outline is as follows

Likenesses Differences

1. Both had shiny surfaces 1. Hammer blue with 4 light blue dull spots

2. Both would give a perfect hook Champion was purple

3. Both cost about the same price 2. Hammer had better control

4. Bowled a complete game with each 3. Bowled 176 with Champion, bowled 215 with Hammer

Have a copy of the passage for the students to read. Have them tell you the Likenesses and Differences as you write them on the board as I have them here. Did they get them all?

Student activities

1. After reading the passage, ask the students to answer the questions about the format mentioned in the beginning.

2. Make a list of attributes discussed in the passage and ask students to decide if they are shared by both or all subjects under the discussion or not shared.

Let them know that they will be comparing and contrasting bridges. The format we just used will be the one they will use and copy as we go through this lesson. Ask if there are questions to be sure they understand, then have them compare-contrast lunches, sneakers, vacation spots, etc. Be sure to have them go over the three(3) types of bridges.

Lesson 2

Compare and Contrast

Purpose: To compare and contrast arch, drawbridges, and cantilever bridges

To identify characteristics of each

Materials: Venn diagrams, pencils, books with pictures of different styles of bridges, Legos, Linking logs, measuring tape

Time: 1 - 1 1/2 hours Class Size Up to 26 working in groups of 2 or 3

Procedure: 1. Read the passages about the three (3) types of bridges in the beginning of this unit. Complete the chart below for each pair of bridges.

Likenesses Differences

Bridges (arch & cantilever)

_____

_____

Bridges (cantilever & drawbridge)

_____

_____

Bridges (arch & drawbridge)

_____

_____

2. Complete three (3) Venn Diagrams noting the likenesses and the differences the three bridge designs. Be sure to use some of the vocabulary words in your explanations.

3. Then using Legos, then Linking Logs, build two types of bridges and complete a Venn Diagram for the two you made. Use pictures.

Conclusion:

1. What types of bridges did you decide to make?
2. Why did you decide to make these?
3. What was similar about your bridges?
4. What was different?
5. What would you have done different it you could do it over?

Parts of a Bridge

There are some parts of the bridges that they all share like the approach, the deck, or roadway, abutments, and the span. Please refer to the books in the children's reading list.

Draw sketches of bridges and label these parts.

There, of course, parts of the bridges that distinguish them from each other like, the lift, piers, cutwater, cables, triangles, and beams. Please refer to the books from the children's reading list.

Draw sketches of bridges and label these parts.

Many bridges have a combination of types in one bridge like part suspension and part truss. Part may be arch and truss. Please refer to the books from the children's reading list.

Draw sketches of bridges and label these parts.

Force and Bridge Design

The foundation and support of these bridges is very important. The work of a bridge is to support itself and its load against the pull of gravity (stress). Stress on a material usually results in strain or a change in the material's shape. There are two types of stress: compression and tension. In a bridge, stress is also caused by the pull of gravity; the amount of stress is determined by the weight of the bridge plus its load. Compression occurs when an object is holding weight. Tension occurs when an object is being pulled or stretched.

The type of bridge designed is directly connected to the kind of stress that will be placed on the bridge. If the bridge will be a pedestrian bridge only then it would not need to be as strong as one that would carry trucks and cars. Steel may not be used. A bridge carrying many cars and trucks at the same time would need to be made sturdy and tough.

Steel, the strongest of all bridge materials may very well be used as well as others. Reinforced concrete is often used. Wood tends to bend and may split so it is unreliable when used in the construction of bridges, especially large bridges.

Assessment:

Name as many parts of bridges as you can.

Which would be used in the construction of your bridge?

Lesson 3

Assembly: The Game - A bridge's strength must be built in from the bottom up

Purpose: To design a game that would require the students to assemble a bridge from the bottom up

To choose appropriate materials to build the bridges in this game

To build model bridges, label the bridge parts, and

Materials: Cardboard (medium and lightweight), plaster of Paris, glue, string, rulers, straws, protractor, pencils, and whatever else the students choose to use, plus the books from the students reading list, scissors, tape, 3 matchbox cars per group, bridge stencils, paper for labels, hole puncher, and twine.

Time: approx. 1-1/2 hours over 2-3 days Class Size: 23-26 (working in 3 groups)

Procedure:

The three bridges that will be assembled in the game are the arch, the cantilever, and the drawbridge. I have made stencils for each type of bridge. They are at the end of this unit.

Blackline masters will be included so that copies can be made on tag board or cardboard for future use of the game. Develop rules for playing the game as a class. Who wins?

The names of the three bridges will each be on a piece of cardboard. Have them face down and shuffled on a table or desk. Have a member of each group choose one. This will be the bridge their group will assemble. Each group should have all of the materials above, even if they don't need them. Refer to books, pictures, and prior lessons to make successful bridges. The finish products should hold up at least three cars.

The parts of the bridges must be cut out, folded, and glued together.

When you are done label the bridge parts and answer the questions below. Good Luck!

Assessment:

1. Which type of bridge did you design, cantilever, drawbridge, or arch?
2. How long is the span?
3. How wide is the roadway?
4. What type of abutments was used?
5. How high the highest point from the water level?
6. Was your bridge hard or easy to assemble?
7. Would you want to do this bridge again?
8. Which bridge was the easiest?
9. What did the bridges have in common?
10. What made them different?
11. What could you do to improve the game?

After they have completed the questions take pictures of your group and your construction.

Unit Wrap up and Extension Activities

Complete the K-W-L Chart. Answer the questions from the center column and write what you learned in the last column.

Make a box and cover for the Assembly Game.

Does the game help you better understand how bridges are put together?

Try to make a LOW bridge in your backyard. Try the suspension type.

Use rope and sticks. This would be great if you have trees that are close together.

Try to make an arch bridge using rocks from outside.

Make three (3) lists. 1) the parts of a cantilever bridge, 2) the parts of an arch bridge, and 3) the parts to a lift bridge.

Which was the easiest to make? Which was the hardest to make?

Record every bridge you cross over or go under for a week. You'll be surprised at the

actual number of bridges you pass.

What are some of the causes and effects involved with building bridges?

Reading Lists

Teacher List

Cortright, Robert S., *Bridging Discovering the Beauty of Bridges* , Bridge Ink, Inc., Tigard, Oregon, 1998 This book shows a wonderful way to observe and design bridges. There are pictures of various bridges and how critics describe them.

Dupre, Judith, *Bridges* , Black Dog & Leventhal Publishers, New York, 1997 This book describes basic bridges and a variety of bridge types. It is important to note some lessons from failures, which it brought out quite well in this book.

Kappraff, Jay, *Connections The Geometric Bridge Between Art and Science* , McGraw-Hill, New York, 1991 This book combines geometry and art and focuses on the relationships of things. Lessons can be developed and expanded from the information in each chapter.

Student List

Carlisle, Norman and Madelyn, *A True Book-Bridges* , Children's Press, Chicago,1983. This book is for the youngest or lowest level students in your class. The words are big and few. The photographs and illustrations are clear. The language is very plain, but quite useful.

Johmann, Carol A. and Rieth, Elizabeth J., *Bridges!* Amazing Structures to Design, Build, and Test, Williamson Publishing Company, Charlotte, Vermont, 1999. This book is full of problem solving activities, challenges, and simple examples and explanations of how bridges are made. A young, future, independent bridge designer would love this book. Most projects use inexpensive, materials found at home, and can be assembled easily if he or she can read the directions. Many illustrations are provided.

MacGregor, Anne and Scott, *Bridges- A Project Book* , Lothrop, Lee, & Shepard Books, New York, 1980. With this fascinating project book, you can learn all about the history of bridges and the architectural and engineering principles of bridge building.

Pollard, Jeanne, *Building Toothpick Bridges* Both teacher and student can use this book. The materials are easy to get and inexpensive. Though there are directions for each bridge it leaves room for creativity.

Sandak, Cass R., *Bridges* , Franklin Watts, New York, 1983 This book explains in simple terms and vocabulary the technology of modern engineering wonders. There are full color photographs and diagrams.

(figures available in print form)