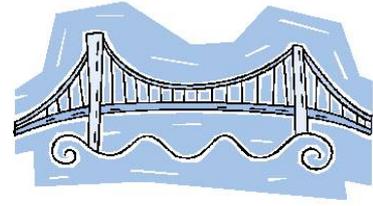




Paddle pop Bridge



Provided by TryEngineering - www.tryengineering.org

Lesson Focus

Lesson focuses on how bridges are engineered to withstand weight, while being durable, and in some cases aesthetically pleasing. Students work in teams to design and build their own bridge out of up to 200 paddle pop sticks and glue. Bridges must have a span of at least 35 cm and be able to hold a two kilogram weight (younger students) or a ten kilogram weight (older students). Students are encouraged to be frugal, and use the fewest number of paddle pop sticks while still achieving their goals. Students then evaluate the effectiveness of their own bridge designs and those of other teams, and present their findings to the class.

Lesson Synopsis

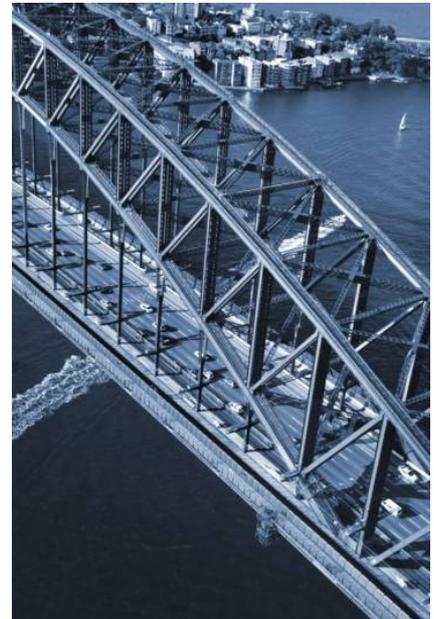
The "Paddle pop Bridge" lesson explores how engineering has impacted the development of bridges over time, including innovative designs and the challenge of creating bridges that become landmarks for a city. Students work in teams of "engineers" to design and build their own bridge out of glue and paddle pop sticks. They test their bridges using weights, evaluate their results, and present their findings to the class.

Age Levels

8-18.

Objectives

- ✦ Learn about civil engineering.
- ✦ Learn about engineering design.
- ✦ Learn about planning and construction.
- ✦ Learn about teamwork and working in groups.



Anticipated Learner Outcomes

As a result of this activity, students should develop an understanding of:

- ✦ structural engineering and design
- ✦ problem solving
- ✦ teamwork

Lesson Activities

Students learn how bridges are designed to meet load, stress, and aesthetic challenges. Students work in teams to design and build a bridge out of up to 200 paddle pop sticks and glue that can hold a standard weight based on the age of the students. Teams test their bridge, evaluate their own results and those of other students, and present their findings to the class.

Paddle pop Bridge

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Resources/Materials

- ✦ Teacher Resource Documents (attached)
- ✦ Student Worksheets (attached)
- ✦ Student Resource Sheets (attached)

Alignment to Curriculum Frameworks

See attached curriculum alignment sheet.

Internet Connections

- ✦ TryEngineering (www.tryengineering.org)
- ✦ Sydney Harbor Bridge History (www.cultureandrecreation.gov.au/articles/harbourbridge)
- ✦ Building Big - Bridges (www.pbs.org/wgbh/buildingbig/bridge)
- ✦ Curriculum links (www.acara.edu.au)

Supplemental Reading

- ✦ Bridges of the World: Their Design and Construction (ISBN: 0486429954)
- ✦ Bridges: Amazing Structures to Design, Build & Test (ISBN: 1885593309)

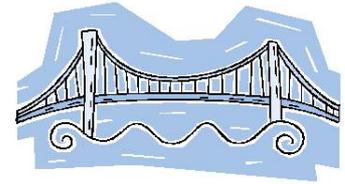
Optional Writing Activity

- ✦ Write an essay or a paragraph about how new engineered materials have impacted the design of bridges over the past century.

Extension Ideas

- ✦ Challenge advanced students to design and build a bridge out of paddle pop sticks and glue that can hold the weight of three students.

Paddle pop Bridge



For Teachers: Teacher Resource

◆ Lesson Goal

Lesson focuses on how bridges are engineered to withstand weight, while being durable, and in some cases aesthetically pleasing. Students work in teams to design and build their own bridge out of up to 200 paddle pop sticks and glue. Bridges must have a span of at least 35 cm and be able to hold a two kilogram weight (younger students) or a ten kilogram weight (older students). Students are encouraged to be frugal, and use the fewest number of paddle pop sticks while still achieving their goals. Students then evaluate the effectiveness of their own bridge designs and those of other teams, and present their findings to the class.

◆ Lesson Objectives

- ✦ Learn about civil engineering.
- ✦ Learn about engineering design.
- ✦ Learn about planning and construction.
- ✦ Learn about teamwork and working in groups.

◆ Materials

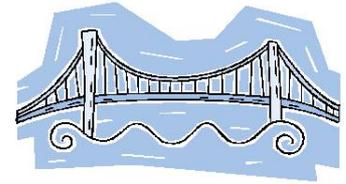
- ✦ Student Resource Sheet
- ✦ Student Worksheets
- ✦ One set of materials for each group of students:
 - 200 paddle pop sticks, hot glue gun (or craft glue for younger students)
 - Standard 2 and 10 kilogram weight (box of sugar, exercise weight, or another weight that can be standardised)



◆ Procedure

1. Show students the various Student Reference Sheets. These may be read in class, or provided as reading material for the prior night's homework.
2. Divide students into groups of 2-3 students, providing a set of materials per group.
3. Explain that students must develop their own bridge from up to 200 paddle pop sticks and glue. Bridges must be able to hold a two kilogram weight for younger students and a ten kilogram weight for older students. The bridge must span at least 35 cm (so it must be longer than 35 cm). When the bridge has been constructed, it will be placed at least one foot above the floor (place it between two chairs, as an example) and tested with a weight bearing test. In addition to meeting the structural and weight bearing requirements, the bridge will also be judged on its aesthetics, so students should be encouraged to be creative. Students will be encouraged to use the fewest number of paddle pops possible to achieve their goal.
4. Students meet and develop a plan for their bridge. They draw their plan, and then present their plan to the class.
5. Student groups next execute their plans. They may need to rethink their design, or even start over.
6. Next....teams will test their bridge's weight capacity by placing it at least one foot above the floor (try using blocks or a chair supporting each end of the bridge). The bridge must be able to bear the assigned weight (depending upon student age) for a full minute.

Paddle pop Bridge



For Teachers: Teacher Resource (continued)

7. Each bridge should be judged by the class in terms of its aesthetic value on a scale of 1-5 (1: not at all appealing; 2: not appealing; 3: neutral/average; 4: somewhat appealing; 5: very appealing). This is of course subjective.
8. Teams then complete an evaluation/reflection worksheet, and present their findings to the class.

◆ Time Needed

Two to three 45 minute sessions

◆ Tips

- For older students, increase the load the bridge must bear....bridges of this type made with hot glue can bear the weight of several students if well executed.
- A glue gun works best for this project, but for safety reasons, we suggest you use craft glue for younger students.

Paddle pop Bridge

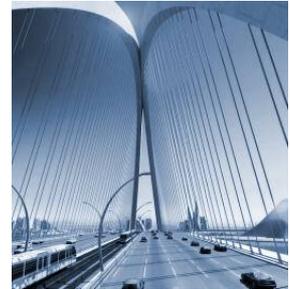


Student Resource: Types of Bridges

There are six main types of bridges: arch, beam, cable-stayed, cantilever, suspension, and truss.

◆ Arch

Arch bridges are arch-shaped and have abutments at each end. The earliest known arch bridges were built by the Greeks and include the Arkadiko Bridge. The weight of the bridge is thrust into the abutments at either side. The largest arch bridge in the world, scheduled for completion in 2012, is planned for the Sixth Crossing at Dubai Creek in Dubai, United Arab Emirates.



◆ Beam

Beam bridges are horizontal beams supported at each end by piers. The earliest beam bridges were simple logs that sat across streams and similar simple structures. In modern times, beam bridges are large box steel girder bridges. Weight on top of the beam pushes straight down on the piers at either end of the bridge.



◆ Cable-stayed

Like suspension bridges, cable-stayed bridges are held up by cables. However, in a cable-stayed bridge, less cable is required and the towers holding the cables are proportionately shorter. The longest cable-stayed bridge is the Tataro Bridge in the Seto Inland Sea, Japan.



◆ Cantilever

Cantilever bridges are built using cantilevers — horizontal beams that are supported on only one end. Most cantilever bridges use two cantilever arms extending from opposite sides of the obstacle to be crossed, meeting at the center. The largest cantilever bridge is the 549 m Quebec Bridge in Quebec, Canada.



◆ Suspension

Suspension bridges are suspended from cables. The earliest suspension bridges were made of ropes or vines covered with pieces of bamboo. In modern bridges, the cables hang from towers that are attached to caissons or cofferdams which are embedded deep in the floor of a lake or river. The longest suspension bridge in the world is the 3911 m Akashi Kaikyo Bridge in Japan.



◆ Truss

Truss bridges are composed of connected elements. They have a solid deck and a lattice of pin-jointed girders for the sides. Early truss bridges were made of wood, but modern truss bridges are made of metals such as wrought iron and steel. The Quebec Bridge, mentioned above as a cantilever bridge, is also the world's longest truss bridge.



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Paddle pop Bridge



Student Resource: Famous Bridges

◆ Firth of Forth Bridge, Scotland

The Forth Bridge is a cantilever, railway bridge over the Firth of Forth in the east of Scotland. The bridge is, even today, regarded as an engineering marvel. It is 2.5 km in length, and the double track is elevated 46 m above high tide. It consists of two main spans of 520 m, two side spans of 205m, 15 approach spans of 51 m, and five of 7.6 m. Each main span comprises 210 m cantilever arms supporting a central 110 m span girder bridge. The three great four-tower cantilever structures are 104 m tall, each 21 m diameter foot resting on a separate foundation. The southern group of foundations had to be constructed as caissons under compressed air, to a depth of 27 m. At its peak, approximately 4,600 workers were employed in its construction.

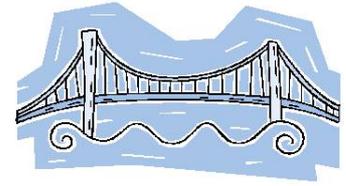


◆ Sydney Harbour Bridge, Australia

The Sydney Harbour Bridge is a steel arch bridge across Sydney Harbour that carries trains, vehicles, and pedestrian traffic between the Sydney central business district and the North Shore area. The dramatic view of the bridge, the harbour, and the nearby Sydney Opera House is an iconic image of both Sydney and Australia. The bridge was designed and built by Dorman Long and Co Ltd, from Middlesbrough, Teesside, U.K., and was the city's tallest structure until 1967. According to Guinness World Records, it is the world's widest long-span bridge and its tallest steel arch bridge, measuring 134 metres from top to water level. It is also the fourth-longest spanning-arch bridge in the world. The arch is composed of two 28-panel arch trusses. Their heights vary from 18 m at the center of the arch to 57 m (beside the pylons).



Paddle pop Bridge



Student Worksheet: Design Your Own Bridge

You are part of a team of engineers who have been given the challenge to design a bridge out of up to 200 paddle pop sticks and glue. Bridges must be able to hold a specific weight (your teacher will decide what the weight goal will be for your class). The bridge must span at least 35 cm in length. But, it must be longer than 35 cm because when it has been constructed, it will be placed between two chairs so it is at least one foot above the floor for a weight bearing test. In addition to meeting the structural and weight bearing requirements, the bridge will be judged on its aesthetics as well, so be creative! And, you are encouraged to use the fewest number of paddle pops possible to achieve your goal.

◆ Planning Stage

Meet as a team and discuss the problem you need to solve. Then develop and agree on a design for your bridge. You'll need to determine how many paddle pop sticks you will use (up to 200) -- and the steps you will take in the manufacturing process. Think about what patterns might be the strongest...but you are also being judged on the aesthetics of your bridge! Draw your design in the box below, and be sure to indicate the number of sticks you anticipate using. Present your design to the class. You may choose to revise your teams' plan after you receive feedback from class.

Number of paddle pop sticks you anticipate using:

Paddle pop Bridge



Student Worksheet (continued):

◆ Construction Phase

Build your bridge. During construction you may decide you need additional sticks (up to 200) or that your design needs to change. This is ok -- just make a new sketch and revise your materials list.



◆ Aesthetic Vote

Each student will cast a vote about the look of each bridge. The scale is 1 - 5 -- (1: not at all appealing; 2: not appealing; 3: neutral/average; 4: somewhat appealing; 5: very appealing). This number is averaged to generate a score for each bridge. This score is not based on how well the bridge might hold weight, but on how it looks.

◆ Testing Phase

Each team will test their bridge to see if it can withstand the required weight for at least one full minute. Be sure to watch the tests of the other teams and observe how their different designs worked.

◆ Evaluation Phase

Evaluate your teams' results, complete the evaluation worksheet, and present your findings to the class.

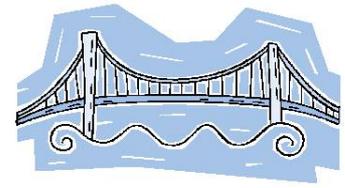
Use this worksheet to evaluate your team's results:

1. Did you succeed in creating a bridge that held the required weight for a full minute? If not, why did it fail?

2. Did you decide to revise your original design while in the construction phase? Why?

3. How many paddle pop sticks did you end up using? Did this number differ from your plan? If so, what changed?

Paddle pop Bridge



Student Worksheet (continued):

4. What was the average aesthetic score for your bridge? How did this compare to the rest of the class? What design elements of other bridges did you like the best?

5. Do you think that engineers have to adapt their original plans during the construction of systems or products? Why might they?

6. If you had to do it all over again, how would your planned design change? Why?

7. What designs or methods did you see other teams try that you thought worked well?

8. Do you think you would have been able to complete this project easier if you were working alone? Explain...

9. What sort of trade-offs do you think engineers make between functionality, safety, and aesthetics when building a real bridge?

Paddle pop Bridge



For Teachers: Alignment to Curriculum Frameworks

Note: All lesson plans in this series are aligned to the Australian Curriculum for both Science and Mathematics.

	Year Level					
	5	6	7	8	9	10
Science Understandings			Change to an object's motion is caused by unbalanced forces acting on the object (ACSSU117) <i>Investigating the effects of applying different forces to familiar objects</i>			Energy conservation in a system can be explained by describing energy transfers and transformations (ACSSU190) The motion of objects can be described and predicted using the laws of Physics (ACSSU229)
Science as a human endeavour			Scientific knowledge changes as new evidence becomes available (ACSHE119) Science knowledge can be developed through collaboration and connecting ideas across the disciplines of Science (ACSHE223)		Advances in scientific understandings often rely on developments in technology and technological advances are often linked to scientific discoveries (ACSHE195)	

	Year Level					
	5	6	7	8	9	10
Science Inquiry Skills			<p>Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge (AC SIS124)</p> <p>Summarise data and use scientific understanding to identify relationships and draw conclusions(AC SIS130)</p> <p>Reflect on the method used to investigate a question or solve a problem, evaluate quality of data collected and identify improvements to the method (AC SIS131)</p> <p>Use scientific knowledge and findings from investigations to evaluate claims (AC SIS132)</p> <p>Communicate scientific ideas and information for a particular purpose (AC SIS133)</p>		<p>Formulate questions or hypothesis that can be investigated scientifically (AC SIS198)</p> <p>Use knowledge of scientific concepts to draw conclusions that are consistent with evidence (AC SIS204)</p> <p>Evaluate conclusions and describe specific ways to improve quality of data (AC SIS205)</p> <p>Communicate scientific ideas and information for a particular purpose (AC SIS208)</p>	

Maths Curriculum Links

	Concept / Year Level							
	Number and place value	Real numbers	Money and financial maths	Linear and non-linear relationships	Using units of measurement	Geometric reasoning	Data and representation and interpretation	Shape
Popsicle Bridge	Yr 5 - 10	Yr 7 - 9			Yr 6		Yr 5 - 10	

Mathematics Links with Science Curriculum (Skills used in this activity)	General Capabilities	Cross-Curriculum Priorities
<ul style="list-style-type: none"> • Process data using simple tables • Data analysis skills (graphs) • Analysis of patterns and trends • Use of metric units 	<ul style="list-style-type: none"> • Literacy • Numeracy • Critical and creative thinking • Personal and social capacity • ICT capability 	

Science Achievement Standards

Year 7

By the end of Year 7, students describe techniques to separate pure substances from mixtures. **They represent and predict the effects of unbalanced forces**, including Earth's gravity, on motion. They explain how the relative positions of the Earth, sun and moon affect phenomena on Earth. They analyse how the sustainable use of resources depends on the way they are formed and cycled through Earth systems. They predict the effect of environmental changes on feeding relationships and classify and organise diverse organisms based on observable differences. Students describe situations where scientific knowledge from different science disciplines has been used to solve a real-world problem. They explain how the solution was viewed by, and impacted on, different groups in society.

Students identify questions that can be investigated scientifically. They **plan fair experimental methods, identify variables to be changed and measured. They select equipment that improves fairness and accuracy and describe how they considered safety. Students draw on evidence to support their conclusions.** They summarise data from different sources, describe trends and refer to the quality of their data when suggesting improvements to their methods. **They communicate their ideas, methods and findings using scientific language and appropriate representations.**

Year 10

By the end of Year 10, students analyse how the periodic table organises elements and use it to make predictions about the properties of elements. They explain how chemical reactions are used to produce particular products and how different factors influence the rate of reactions. They explain the concept of energy conservation and represent energy transfer and transformation within systems. **They apply relationships between force, mass and acceleration to predict changes in the motions of objects.** Students describe and analyse interactions and cycles within and between Earth's spheres. They evaluate the evidence for scientific theories that explain the origin of the universe and the diversity of life on Earth. They explain the processes that underpin heredity and evolution. Students analyse how the models and theories they use have developed over time and discuss the factors that prompted their view.

Students develop questions and hypotheses **and independently design and improve appropriate methods of investigation**, including field work and laboratory experimentation. They explain how they have considered reliability, safety, fairness and ethical actions in their methods and identify where digital technologies can be used to enhance the quality of their data. **When analysing data, selecting evidence and developing and justifying conclusions, they identify alternative explanations for findings and explain any sources of uncertainty.** Students **evaluate the validity and reliability of claims made in secondary sources with reference to currently held scientific views**, the quality of methodology and the evidence cited. They construct evidence-based arguments and select appropriate representations and text types to communicate science ideas for specific purposes.