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Bridging The Gap: Math to Science

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Introduction

Imagine the world without bridges. How easy would it be to travel to the mall? How about to visit someone in another city? Life without bridges would not exist, as we know it. The first bridges were built as a result of a need to make life and travel easier.

The first bridges were provided by nature. A tree or trees would often fall across a stream or river. This would provide a natural bridge. Debris and stones carried by streams would settle in shallow spots and provide a type of bridge. In the jungle, vines were used to swing over water.

Modern bridges evolved in part due to the natural bridges. Fallen logs evolved into beam bridges, Stone piles evolved into piers and arches. Suspension bridges were a natural development in warm climates where there were plenty of vines available to make bridges. This unit will attempt to teach math and science concepts using data that demonstrates the important role of bridges in the world and in our lives.

Objectives

Math

- Classify and measure angles
- Draw angles and estimate measures of angles
- Construct congruent segments and angles
- Solve problems by drawing diagrams
- Make scale drawings
- Find actual length from a scale drawing
- Write and solve proportions by using cross products
- Calculate fractional parts of a whole

Science

- Prepare tables of selected bridge spans
- Interpret data from a table
- Use data from tables to make graphs
- Review SI units of measure
- Compare SI to standard units of measurement
- Learn to apply the Scientific Method to problem solving

Vocabulary

Girder. A large beam providing strength and support for a structure. Inertia. The tendency of matter to remain at rest or continue in a fixed direction unless affected by an outside force. Live load. A load that is applied to a structure to determine its dynamic behavior. Mass. A quantity of matter. Mode. A characteristic shape of a structure when it is vibrating. Moment. Force applied to a body in such a way as to produce rotation or twisting. Torsion. Twisting motion. Truss. A framework consisting of many interconnected braces used to support a structure. Yield stress. The point at which a material can no longer sustain a given load without permanent deformation.

Purpose

This unit is designed to be presented to 6th grade inner-city students. The unit seeks to find different and creative ways to develop student interest in Math and Science. Many of our students are grade levels behind in math and have had very little exposure to physical science. Hopefully this hands-on approach will create an interest. Being able to apply the concepts learned to a practical project should help make learning more meaningful to students.

The unit is designed to be taught over one marking period approximately 10 weeks. As a kick-off of the unit, each student will be required to visit a bridge of their choice. They will be asked to write a short narrative and make a sketch of what they observed. Before they reach the design stage, students will be taken on a field trip to visit a bridge in the Fair Haven or downtown area. Most of my students live in or around these areas.

My classes are inclusion classes, which mean regular education, special education and bilingual students are in the same class. Work has to be modified to meet the needs of all the students. This unit should be very useful in my class, since it is designed for students to use different and individual means of expressing their knowledge. I plan to use the corporate learning group approach to teach this unit. To the extent possible and with agreement from the students, groups will be formed based on student abilities and strengths.

The end product a (Bridge) will be treated as a culminating activity. Each individual or group will be encouraged to complete a bridge, however, it is not necessary. One will be completed as a class project.

The unit will incorporate math and science concepts defined by the Board of Education and my school's Comprehensive School Plan. These concepts and objectives will be taught and applied to come up with two end products; a completed bridge and a short research paper. The idea that students can use the knowledge they have acquired to make something they can identify with, should add real world meaning to what they have to learn and increase their interest in learning.

In my science class, which is physical science, students will be introduced to the Scientific Method, SI (metric) measurement and conversion from Standard to Metric units. Since students do not have much knowledge of the SI system, quite a bit of time will be spent on this. Students will learn the relationship of SI units to Standard units (Example 30 cm equals 12 in). Classes will cover measurement, mapping skills, graphing, scale drawing and estimation. Students will be presented with many hand-on activities where these concepts can be applied.

In math class many objectives relative to this unit will be covered, including geometry, measurement, ratio and proportion and proportional reasoning. Students will be required to use the Internet Connection included in every chapter of the text to find background information relating to their project and research paper. Before starting to construct the design for their bridge, I would like for students to have knowledge of the "Why and How" of bridge design.

As a result of the Internet research, class discussion, and individual visit to a bridge and a class visit to a bridge, students will be able to come up with question relating to bridges that they would like to answer. This will make the start of the Scientific Method. The Scientific Method will include the following steps:

1) Choose a problem (their question)
2) Research your problem
3) Develop a hypothesis
4) Write your procedure
5) Test your hypothesis
6) Organize your data
7) State your conclusion

Completion of the seven steps of the Scientific Method should provide the information needed to complete their research paper. To add variety to the projects, students will be required to select a type of bridge to focus their study. They will build the bridge of their choice and complete a research paper.

Once the preliminary activities are completed, students will be assessed at two-week intervals during the marking period. As part of the assessment, students will be required to complete a "'Dream Bridge." They will be required to draw a scaled version of the bridge. They may use any sturdy material to complete their bridge.

When completing the bridge, some students will use the Standard unit of measurement and others will us SI. Completed projects will be presented to class. A spokesperson from each team will be required to explain their group project.

Judging of the bridge will be done using a rubric. Students will participate in the construction of the rubric. For most of my students, this will be their first exposure to a rubric. To get students comfortable with using a rubric, we will practice by scoring open-ended questions in math class. This will serve two purposes.

1) To get students accustomed to writing out explanations to math problems.
2) Teach students how to evaluate their own work before it goes to the teacher.

This knowledge, especially # 2 will be helpful when my 6th graders the Connecticut Mastery Test (CMT) in 8th grade. They will be required to write an essay that is holistically scored using a rubric. Students who become proficient with the rubric will be able to self-score their essay.

The culminating activity for this unit will be a "fair." For the fair all classes will come together. Those chosen by their classmates to participate on the fair will be required to explain their project. For teams there will be only one spokesperson. Judging of the projects will be done using a rubric.

Bridge Timeline1

The earliest bridges area the unintended results of trees falling across rivers or gorges. As early man begins to travel farther and farther away from home, natural bridges are a handy way to cross rough terrain.

- 0600 AD. The durable An-chi Bridge at Chao Chou is designed and built by Li Ch'un. The 117 feet span features arch-shaped openings on the walls of the bridge.
- 1400. The Romans' innovative design for an aqueduct bridge is built in Nimes, France. It is used to transport water from the Gard River to the town of Nimes. Its unique design consists of three tiers of arches. It is extremely strong so that it can withstand the weight if water.
- 1500. Bridge design begins to accelerate during this time. Designs now include chapels, resting places, towers, iron gates and even shops and houses.
- 1700. Moving bridges became a necessity as the rapid growth of industry and the need for supplies to be shipped between cities means an increase in boat travel on canals and rivers.
- 1781. The iron bridge is completed on Coalbrookdale, England. It is the first, and largest bridge

constructed completely of iron using traditional wood joining techniques.

• 1800. Wagon bridges became the bridge of choice in America

• The first American truss bridge design is patented. Truss bridges are more popular in America than anywhere else in the world.

• 1850. The landmark Britannia Bridge is built over the Menia Straits by Robert Stephenson. It is designed to carry the Chester and Holyhead Railway over the Menai Straits in Wales.

• 1857. The First steel-making machine is patented by American inventor William Kelly. This machine makes it possible to produce steel cheaper. British inventor Harry Bessemer goes even farther with a technique for Steel-making that is still used.

• 1867. Joseph Monier develops a method of making concrete stronger by reinforcing it with iron mesh.

• 1879. The Tay Bridge in Scotland Collapses. This marks the beginning of the search to find a material to replace iron in bridge building.

• 1890. In Scotland, the Firth of Forth Railway Bridge is completed. Unique in its look this bridge is constructed out of 58,000 tons of steel.

• 1894. The tower Bridge is completed in London. This bridge is one of the first lifting bridges to use steel in its construction. Two steel platforms, weighing 1,100 tons, are lifted into place using hydraulic equipment.

• 1900. One of the first examples of a suspension bridge is built to span 1,800 feet over the Min River in China.

• 1904. Eugene Feryssinet develops pre-stressed concrete. Pre-stressed concrete has metal placed throughout the concrete while it is still wet.

• 1932. The Sydney Harbor Bridge is completed. The bridge's deck, which carries eight lanes of road traffic, four rail tracks, and two footpaths, still holds the world's record for the heaviest load.

• 1965. One of the world's longest suspension bridges, the Verrazano-Narrows Bridge is built in New York City. The bridge spans 4,260 feet to connect Brooklyn and Staten Island.

• 2000. In the future, the world's longest single span in a suspension bridge 6,528 feet long will be Japan's Akashi Kaikyo Bridge. Another impressive bridge may be one that has always dared humankind. If built the 55 mile long bridge proposed by T.Y. Linn would span the Bering Strait to connect Russia and Alaska.

Types of Bridges2

Modern Bridge Design

There are six basic modern bridge forms, the beam, the truss, the arch, the cantilever, the cable stayed and the suspension. A beam or "girder" bridge is the simplest and most inexpensive kind of bridge to construct. It is made of long timber, metal or concrete beams anchored at each end. In its most basic form, a beam bridge consists of a horizontal beam that is supported at each end by piers. The weight of the beam pushes straight down on the piers. The beam must be strong so that it does not bend under its own weight and the added weight of crossing traffic. When a load pushes down on the beam, the beam's top edge is pushed together (compression) while the bottom edge is stretched (tension). If the beams are arranged in a lattice, such as a triangle, so that each component shares only a portion of the weight on any part of the structure, the results is a truss bridge.

Arch bridges are one of the oldest types of bridges; they have great natural strength. Instead of pushing straight down, the weight of an arch bridge is carried outward along the curve of the arch to the supports at each end. These supports, called the abutments, carry a load and keep the ends of the bridge from spreading out. Bowed shapes causes the vertical force of the weight it carries to produce a horizontal outward force at its ends. Arched bridges can be constructed of steel, concrete, masonry or wood.

A cantilever bridge is formed by self-supporting arms anchored at and projecting toward one another from the ends; they meet in the middle of the span where they are connected together or support a third member.

Cable-Stayed bridges may look similar to suspension bridges, both have roadways that hang from cables and both have towers. The two bridges, however, support the load of the roadway in very different ways. The difference lies in how the cables are connected to the tower. In suspension bridges, the cables ride freely across the towers, transmitting the load to the tower and the anchorages at either end. In cable-stayed bridges, the cables are attached to the towers, which bear the load. The cables can be attached to the roadway in a variety of ways. In a radical pattern, cables extend from several points on the road to a single point at the top of the tower. In a parallel pattern, cables are attached at different heights along the tower, running parallel to each other.

The modern era of bridge building began with the development of the Bessemer process for converting cast iron into steel. It became possible to design framed structures with greater ease and flexibility. Single-piece, rolled steel beams can support spans of 50 100 feet (15-30) meters, depending on the load. Larger, built-up beams are made for longer spans; a steel box-beam bridge with an 850-ft {260} meters span crosses the Rhine at Cologne.

Truss, Arch, and Cantilever Bridges

The truss can span even greater distances and carry heavy loads; it is therefore commonly used for railroad bridges. A large truss span like that over the Columbia River at Astoria OR, can extend to 1,232 feet (376 meters). If the truss is shaped into an arch, even longer bridges are possible; such as the Bayonne Bridge between New York and New Jersey, the Sidney Harbor Bridge in Australia and the New River Bridge in West Virginia are the longest steel arch bridges at 1,675 feet (510 m), 1,670 feet (509 m) and 1,700 feet (518 m), respectively. Concrete arch bridges tend to be somewhat smaller, the largest being the Krk Bridge in Croatia and the Gladsville Bridge across the Parramatta River at Sidney, Australia, at 1,280 feet (390 m) and 1,000 feet (305 m), respectively. The longest concrete arch bridge in the United States is the Natchez Trace Parkway Bridge in Franklin TN, at 582 feet (177 m). The cantilever however is more common for spans of such lengths. The cantilevered Forth Bridge (1890) in Scotland was the first major structure built entirely of steel, the material that made possible its two record-setting spans of 1,710 feet (521 m) each. They remained the longest in existence until 1917, when the bridge over the St. Lawrence River in Quebec was built; it achieved a 1,800 feet (549m) span. The longest cantilever bridge in the United States is the Commodore John Berry Bridge in Chester, PA, which has a 1,644 feet (501 m) span.

Cable-Stayed, Suspension, and Combination Bridges

The cable-stayed bridge is the most modern type, coming into prominence during the 1950's. The longest is the Tatara Bridge in Ehime, Japan. It has a 2,920 feet (890 m) span. The Ponte de Normandie in Le Havre, France spans 2,808 feet (856 m). The Yangtze Bridge in Nanjing, China spans 2,060 feet (638 m); the Yangtze Bridge in Wuhan, China spans 2,028 feet (618 m). The longest cable-stayed bridge in the United States is the Dame Point Bridge in Jacksonville, FL with a span of 1.300 feet (396 m).

The suspension bridge is used for the longer spans. The earliest suspension bridges built in America were those constructed by the American builder James Finley. The design of suspension bridges advanced when J.A. Roebling, a German born engineer developed the use of wire cables and stiffening trusses. His first completed suspension bridge spanned the Niagara River in 1854. He also designed the Brooklyn Bridge across the East River in New York City (completed in 1883). When completed, it was the world's longest suspension bridge at the time of its construction, having a main span of 1,595 feet (487 m)

Today the longest spans in the world are suspended. The longest main spans are:

- The Akashi Kaikyo Bridge, Hyogo. Japan, 6,529 feet (1,900m).
- The Izmit Bay Bridge, Marmara Sea Turkey, 5472 feet (1668 m).
- The Store Baelt Bridge, Denmark, 5,328 feet (1624 m).
- The Humber River Bridge, Hull, England, 4,626 feet (1,410 m).
- The Tsing Ma Bridgem Hong, Hong, 4,518 feet (1,377 m).
- The Verrazano-Narrows Bridge in New York City, 4,260 feet (1,298 m)
- The Golden Gate Bridge, San Francisco, 4200 feet (1,280 m).
- The Hoga Kusten (High Coast) Bridge, Vasternorriand, Sweden, 3,969 feet (1,210 m).
- The Mackinac Straits Bridge, MI, 3,800 feet (1,158 m).
- The Minami Bisan-Seto Bridge, Japan, 3,668 feet (1,118 m).
- The Second Bosporous Bridge, Istanbul, Turkey, 3,576 feet (1,090 m).
- First Bosporous Bridge, Istanbul, Turkey. 3,524 feet (1,074 m).
- The George Washington Bridge, New York City, 3500 feet, (1,067 m)

Combination spans are often used to bridge even longer stretches of water. The San Francisco-Oakland Bay Bridge noted for its three long spans, of which two are suspension spans and the third a cantilever, has a total length of 8.25 miles (13.4 km). The Chesapeake Bay Bridge-Tunnel has 2 - mile (1.6 km) tunnels along its 17.6- miles (28.2 km) length. The 8-mile (12.9 km) Confederation Bridge linking Prince Edward Island to the Canadian mainland consists of three bridges. The longest combination spans are the twin Lake Ponchartrain Causeways near New Orleans, LA. Their parallel roadways stretch nearly 24 miles (38 km).

Movable Bridges

Movable bridges are generally constructed over waterways where it is impossible or prohibitive to build a fixed bridge high enough for water traffic to pass under it. The most common types of movable bridges are the lifting, bascule, and swing bridges. The lift bridge consists of a rigid frame carrying the road and rest abatement, over each of which rises a steel-frame tower. The center span, which in existing bridges is as long as 585 feet (178 m), is hoisted vertically. The bascule bridge follows the principle of the ancient drawbridge. It may be in one span or in two halves meeting in the center. It consists of a rigid structure mounted at the abutment on a horizontal shaft, about which it swings in a vertical arc. The lower center span of the famous Tower Bridge in London is of the double-leaf bascule type. Because of the need for large counterweights and the stress of hoisting machinery, bascule bridge spans are limited to about 250 feet, (27 m). The swing bridge is usually mounted on a pier in midstream and swung parallel to the stream to allow water to pass.

Military Bridges

In wartime, where the means of crossing a stream or river is lacking or the enemy has destroyed a bridge, the military bridge plays a vital role. Standard types of military bridges include the trestle, built on the spot by the engineering corps from any available material, and the floating bridge made with portable pontoons.2

Methods of Supporting Bridges3

Temporary Support Method. This is perhaps the most traditional and common method. As its name implies, temporary supports are placed at midpoints between piers and abutments. The pieces of the bridge are then put in place, supported by the temporary supports, and joined together. When the entire girder (one span) is complete, the temporary support can be removed.

The temporary support method requires that the locations for the supports be clear and stable. Often the ground is not sufficiently stable and it is necessary to construct foundations for the temporary supports because of the weight they will bear. The assembly and removal of temporary supports require lots of equipment and labor. Even so, it is one of the cheapest and most commonly used methods.

Cable and Tower Method. Often conditions under the bridge are not suitable for the use of temporary supports. This can happen when the valley or ravine is too deep, the flow of the river is too rapid, or environmental reasons prevent the use of temporary supports under the bridge. If conditions on both sides of the bridge are suitable to erecting towers and placing cable anchorages (just like a suspension bridge), the cable erection method can be used.

There are two basic versions of the cable erection method; the diagonal cable method (much like a cable-stayed bridge) and the vertical cable method (much like a suspension bridge). In both methods, cables stretched between the two towers suspend a crane that carries the parts to their location for placement and attachment.

In the diagonal method, cables extended directly from the tower tops. The girder supports the semi-complete bridge. The tension in each individual cable must be carefully monitored and adjusted to maintain balance and keep the structure in its proper position.

In the vertical method, a structure much like a suspension bridge is created to support the bridge during erection. Support girders are hung from each hanger rope and serve as temporary supports. The main cable tension must be adjusted to keep the structure from sagging during erection.

Cable erection is a complex and difficult erection method. Steel cables stretch and elongate under heavy loads. As more weight is added to each support cable, it stretches changing the balance. This makes calculations and management of the erection quite difficult.

Cantilever Method. A cantilever generally refers to a beam or girder that is unsupported on one or more ends. A diving board is a good example of a common cantilever as it is supported on only one end.

In perhaps the most common cantilever erection, the side spans are erected first (often using temporary supports). These side spans then serve as counter weights as the girder is assembled toward the center. Once the girder is joined at the center the bridge is complete and there are no cantilever sections.

The longer the cantilever the greater the forces that occur at the support. Just as a diving board sags more and more the closer the diver gets to the far edge, greater and greater forces are at work the longer the unsupported section becomes. Special care must be taken to make sure the cantilevered section is stable and can withstand the forces at work on it.

Large Block Method. The large block erection method is perhaps one of the most simple and elegant. Very large sections of the bridge, in some cases the entire bridge, are put in place at one time. There are many advantages to being able to do this.

First, it reduces the amount of work that must be done at the site. Since the bridge or block can be assembled before shipping, it can be done in a safer and more controlled environment. If this work is at the production workshop, this can reduce costs, as there is no need to mobilize large amounts of people and equipment,

Second, there is less risk involved. Since the bridge is assembled on the ground workers are not placed at risk in high or dangerous places. There is also less risk of the bridge collapsing midway through the erection process or of damage to the individual parts during shipping or erection.

One other advantage is that large block erection can significantly shorten the length of time required for the project. The amount of time spent erecting temporary supports or scaffolding can be cut to almost zero.

On the other hand, large block erection can only be performed in certain special cases. The location must be one that will allow the entire bridge or large block to be transported from the fabricator to the job site. This method also requires the use of a crane or cranes large enough to lift the entire bridge or block. Sufficient heavy equipment and a route of travel for it must be available. In Japan this method is often used with bridges near the sea or on large rivers. The entire bridge or large parts of it are carried on barges. They are then put on place by huge floating cranes. The largest crane can carry 4,100 metric tons (9 million pounds).

Bridge Building Materials4

As previously stated, early bridges were constructed from commonly found materials like stone (concrete), weed and vines.

Wood. As a bridge building material, wood is strong in relation to its weight. Under stress, the wood type and grain determine its strength. Since wood will bend and split easily, its strength is unreliable. When a plank's width is doubled, its carrying capacity is doubled. When the same plank's height is doubled, its carrying capacity is quadrupled.

Iron. As a result of the Industrial Revolution, methods were developed to mass-produce iron in large quantities. Iron is about four times as strong as stone and thirty times stronger than wood. There are two ways to make iron: Wrought and cast. Wrought iron is stronger under tension than cast iron.

Concrete. Concrete is made from a combination if sand, pebbles, artificial aggregates and cement. Concrete is very strong under compression and is a natural building material for arches, which are also strong under compression. The introduction and development of concrete gave bridge building a much-needed boost.

Steel. Steel, in relation to its weight is the strongest of all bridge building materials. It is 20% stronger than wrought iron. Steel is resilient, more flexible than iron and can be cut. This flexibility of steel makes it ideal for suspension bridges where the cables can shift 2 to 3 feet.

Physical Forces & Bridge Design5

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. A member bearing weight under compression. Hard stone like granite, can withstand and enormous compressive force before losing its shape.

Weight. Compared to the massive amount of dead-weight carried by each pier, the weight of moving objects on a bridge is insignificant

Tension. A member being pulled is under tension. Granite, under tension, will break apart under a small amount of strain. In fact, a long beam of unsupported stone will crack under its own weight.

Structure. If a diagonal is placed across a rectangular frame, the shape becomes rigid and forms two triangles. Triangles are the simplest figure whose shape can't be altered without changing the length of one or more of its sides.

How Steel Bridges are Made5

Pre-Fabrication. Once the final bridge design has been completed, the design plans must be converted into fabrication plans and data. Steel plates often do not come is the size need, so they must be cut to the size needed. Steel is ordered to cover the total amount needed to complete the bridge and part.

Cutting and Marking. Once the steel arrives it must be marked and cut. Using data from a CAD system marking and cutting is performed by a gas and plasma NC torch. Marking is a process, which leaves important indicators on the steel to show the location of stiffening ribs and flanges. These markings become necessary during the assembly process.

Butt Welding. The process of welding one end of a steel plant to another plate to create a continuous plate that changes in thickness and or material. This process is generally performed using a welding process known as submerged arc welding.

Drilling. Once all the plates have been cut and butt-welded, any boltholes must be drilled. Again, the CAD generated fabrication data is used to insure highest quality. A high-speed NC gantry drill is used to drill the boltholes.

Panel Assembly. Once the plates are ready they must be assembled into the girder they are to become. There are two steps involved when fabricating a box girder or part of a steel deck. Large box girders and steel decks have many stiffening plates, which must be welded into the webs and flanges. Since it would be difficult to weld these stiffeners in place after the box girder has been assembled, they are welded into the flange and web plates creating panels for the final assembly.

Assembly, Welding and Correction. Once the panels are complete, the girder is ready to be assembled into its final form. Again tack welding is used to hold the flanges and webs in place prior to welding.

Trial Assembly. The final check before painting and shipping the members is the trial assembly. The whole bridge or sections of it are temporarily assembled. This is done to assure that the parts fit and everything is aligned perfectly before the product is shipped.

Machining. Machining also known as milling is a process in which steel is carved or ground away. On special projects, such as towers for cable stayed of suspension bridges, the adjoining block surfaces are required to come in perfect contact without gaps or spaces on as much as 50% of their contact area.

Blasting. Once the products pass the trial assembly test, they are ready to be painted. First all rust and dirt is cleaned off in blasting chambers. Blasting is done by literally blasting the steel with high-pressure air containing countless tiny bits of metal or sand known as shot. These little bits remove the rust, clean the surface and at the same time slightly roughen the surface of the steel, which helps the paint to adhere.

Painting. Once all the rust has been removed, the parts are painted to specification. Continuous monitoring of the painting process insures a perfect coat.

Lesson Plan I

Objective: research the history of bridges

Procedure:

1) Students will be required to find out how the idea of a bridge was conceived and when and where was the first bridge constructed.
2) Students will gather information on the characteristics of the six types of bridges covered in this unit, (beam, truss, arch, cantilever, cable stayed and suspension).
3) Students will identify types of materials used to construct bridges.
4) Students will use their information to choose a bridge they would like to focus on for this marking period.
5) Each student will turn in a written report.
6) Students will be encouraged to use the Internet to obtain information.

Evaluation: Work will be evaluated based on the information provided, neatness and correct grammar.

Follow-up Activity:

Students could use the Internet to find a picture and additional information on the bridge they chose, such as the longest bridge of its type and where it is located.

Lesson plan 2

Objective: 1) Visit a bridge

Procedure:

1) Students will be required to visit a bridge, preferably in their neighborhood. This can be a group trip or an individual visit.
2) Teacher will assist students in locating a bridge if necessary.
3) Students will make a sketch of the bridge.
4) Students will try to identify the type of bridge, and tell if it's a pedestrian or a vehicle bridge or both.
5) Students will give a brief oral overview of their experience.

Evaluation:

Each student should have a sketch of a bridge. They should be able to describe the type of bridge it is and what it is used for.

Lesson plan 3

Objective: To understand tension and compression

Procedure:

1) Students will find the definition of tension and compression.
2) Students will describe how tension and compression occurs.
3) Students will demonstrate tension and compression.

The Internet can be used to get illustrations of each.

Note to teacher: The Euclidean and Non-Euclidean Geometry with The Geometer's Sketchpad would be very useful for turning this activity into a computer activity.

Evaluation:

Each Student should be able to define tension and compression and show an

Illustration. Extra credit should be given to students who construct a demonstration

This activity may be used in conjunction with this lesson6

Have students build a people bridge to experiment with the forces of compression (a pushing, squeezing force), tension (a pulling force and torsion (a rotational twisting force). Have pairs of students face each other with palms touching and feet 0.5 m (1.5 ft) apart.

Have students slowly move their feet back while keeping their palms touching until the bridge feels balanced and they cannot move back any further without falling down. Where on the bridge do students feel forces of compression and tension? Have one person move two steps to the left.

What happens to the balance of the bridge? How does torsion affect the stability of the bridge? What forces might cause the support structure of a real bridge to rotate?

Students should be allowed to discuss these questions in small groups and come to a consensus on the answers. One person designated as the recorder, should write up the report for submission to the teacher.

Students who have decided to build a suspension bridge for their project, may be interested in demonstrating this activity to the class.

What are the anchorages for?6

Tie two loops of string around the tops of two hard cover books of similar size. Tie a third string to each loop so that it hangs loosely between the books. Press down on the center string. What happens?

Next, stand the two books about 10 inches apart. Put a stack of heavy books on one end of string to secure it to the table. Then pass the string over each book (letting some string hang loosely between the books). Place a second stack of books on the other end of the string. Press again on the center string.

What happens? Notice how the anchorages (stacks of books) help to stabilize the bridge.

This activity could be used at any time to generate or maintain student interest in the unit.

What happens when a load pushes down on a beam bridge?

Take a flat eraser or a small sponge and slice a shallow notch across the top and bottom. Create a beam bridge by supporting each end of the eraser (or sponge) with a stack of books. Press down on the center of the bridge.

What happens to the top and bottom notches? Notice how the top notch squeezes together in compression while the bottom notch spreads apart under tension.

In addition to the applications included in the unit, there are many more applications that can be adapted to teach skills. Ratio and proportion can be used to compare different types of bridges. Students can practice Scale drawing by drawing a sketch of a bridge using a scale. Students can practice estimating length and height by using a scale drawing.

Measurement and measurement conversion can be taught by requiring students to measure in one unit of measure and convert to the other unit. Students could be required to explain the operation (add, subtract, multiply or divide) required to go from a smaller unit to a larger unit and vise versa.

Since my class are inclusion classes (special and regular education) all of my students will not be read to go to Euclidean and Non-Euclidean Geometry with the Geometer's Sketchpad, I would suggest that teachers start their computer exercises with Math Blaster Geometry. This is a fun and non-threatening way to introduce students to geometry.

Notes

1Kelvin Electronics, Hands-on Learning, Bridge Building

2 http://www.mastsuo-bridge.co.jp/english/bridges/erection/support/shtm

3 www.matsuo-bridge.co.jp

4 www.pbs.org/wgbh/nova/teachersguide/bridge

5 www.pbs.org/wgbh/nova/bridge/meetbeam.html

6 www.pbs.org/wgbh/nova/teachersguide/bridge/

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