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CAREER & TECHNICAL EDUCATION

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*Users must

Learning Activity: The United Bridge

This learning activity is designed to introduce students to structural engineering. In this learning activity students will investigate the effects of a deteriorating bridge on the towns in the surrounding area. In addition, students will recommend to the highway department and residents whether the bridge should be remodeled or torn down and rebuilt.

Tools and Materials

The following learning activity will require students to work in small groups. Each group will need access to the following tools, materials and resources:

- Paper
- Paper clips
- Masking tape
- Books
- Pennies or small weights
- Pictures of: Golden Gate Bridge, Brooklyn Bridge, Iron Bridge, Confederation Bridge, and Firth of Forth Bridge (from books, magazines, or the Internet)
- Toothpicks
- Straws
- Popsicle sticks
- Graph paper or poster board
- Drawing boards
- Balsa wood (recommend 1/8 inch)
- Wood glue
- Wax paper (to cover the work area)
- Exacta knife (for cutting the balsa)
- Computer/Internet access (optional)

Objectives:

Upon completion of this learning activity, students should be able to:

- Identify the difference between a dead load and a live load.
- Explain the forces: compression, tension, torsion, and shear.
- Explain why a bridge is important to a community or

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communities.

- Explain why a bridge is shaped the way it is.
- Identify at least two types of bridges.
- Identify at least two types of materials used to build bridges and explain why that material is used.

Articulation with Wisconsin Technology Education Academic Standards

This learning activity will provide opportunities for students to achieve the following Wisconsin Technology Education Academic Standards.

- Analyze various systems and identify the ways in which they are controlled to produce a desired outcome. (B.8.2)
- Identify potential sources of failure in a system; such as, defective parts, maintenance needs, a large number of complex components, or use in applications beyond its original purpose. (B.8.3)
- Discover that resources are essential; they must be used effectively to produce a desired outcome, and outputs from one system may be inputs to another system. (B.8.4)
- Evaluate large and complex systems to determine the ways in which they are creations of human ingenuity. (B.8.5)
- Identify all the resources necessary for a given system; analyze how the use of the resources will be affected by application, and regard for the environment. (B.8.6)

The Human Connection

(Excerpted, in part, from UW-LaCrosse's Global Engineering website (http://www.uwlax.edu/globalengineer/))

Although only a few can name the Seven Wonders of the World, most people know they exist. The histories of some of the most famous structures date back as long ago as the 5th century B.C. In the modern era, the construction process and the ability to build massive and fascinating structures often goes unnoticed even though their roles are extremely important and functional to society. In order to continue to meet the needs and demands that evolve around structures and our ability to continue expanding our capabilities of building structures anywhere there is a need, engineers and architects have developed and applied the abstracts of mathematics and physics to solve practical, real world problems. By doing this, builders can construct useful, efficient structures. These structures include roads, bridges, houses, office buildings, monuments and walls.

In the modern era, structures such as bridges often go unnoticed even though their function is extremely important. In the 1800's, covered wagons heading west had to cross streams and rivers. Without adequate bridges in place, pioneers would sometimes travel many miles to find a safe place to cross a river. In society today, bridges are used regularly. Automobiles use them to cross major bodies of water to get from one place to another, pedestrians use them in cities to cross major highways, people use them to cross streams in parks, on trails, or simply during recreational activities, such as golf. These list a few examples of the importance of bridge structures and their uses in our society today.

In Brooklyn, New York, the construction of one of the most remarkable structures of its time was completed in 1883. This bridge, an example of a suspension bridge, was twice the distance of any other bridge built before, covering 6,016 feet in length (including the approaches). The bridge was also to use pneumatic caissons which allowed people to work under water to make the foundations. Although the completion of the Brooklyn was a remarkable achievement in itself, what was more fascinating was the final completion of the bridge was overseen by a woman named Emily Roebling. Emily became the field engineer after the design engineer, her father-in-law, passed away in 1865 and her husband became paralyzed after an accident. Emily Roebling was the first woman to address the American Society of Civil Engineers.

A more recent structure, built in 1997, was the Confederation Bridge, which spans the Northumberland Strait that connects Prince Edward Island to New Brunswick, Canada. The Confederation Bridge, spanning over 8 miles long, is one of the longest continuous bridges over a single body of water in the world. The bridge is the first to be built completely relying on GPS technology. The uniqueness of this bridge is enhanced when you consider it was built in an area where mountains of ice are the norm five months out of the year. These weather conditions forced the bridge to be designed and built off-site in sections. The bridge was then assembled on-site using GPS satellite positioning technology. Each piece of the bridge needed to be placed in exactly the correct position. The entire eight-mile span had room for only a few inches of error. To accomplish this accuracy, several GPS systems were used in tandem, which provided accuracy to within one quarter of an inch.

Prior Knowledge

Bridges come in many different sizes and shapes. Bridges must support their own weight (**dead load**) and the load that is placed on it (**live load**). There are several types of bridges that support the loads differently. ***Beam bridges*** use trusses to support loads. ***Arch bridges*** distribute the load on the bridge to the ground. ***Suspension***

bridges carry most of the load in the cables. Some examples and descriptions of both early and modern bridge designs are listed below.

Early Bridges

The earliest bridges consisted mainly of logs that had fallen or were placed across rivers. Although these bridges were inexpensive, they were unreliable. Moving heavy loads across them was almost impossible. ***Primitive rope bridges*** were nothing more than a cable or rope stretched across a river. People could cross, but the rope was not practical for moving heavy goods. These rope bridges were the forerunners of modern suspension bridges. ***Sophisticated rope bridges*** are still in use in many parts of the world. They allow light loads to be moved across rivers. While suitable for foot travel and pack animals, motorized traffic would have difficulties crossing on them. Also, high winds on a rope suspension bridge causes serious dangers.

Modern Bridge Designs

The ***stone arch bridge*** design is among the strongest and most durable bridges. Stone is a naturally strong and enduring material for a bridge. In a stone arch bridge, the stones are pressed against each other. Labor costs for transporting the stones for these types of bridges are great. ***Steel arch bridges*** are also capable of covering great spans and bearing heavy loads. An example of this type of bridge is the Gateway Arch in Saint Louis.

The ***suspension bridge*** is capable of covering longer spans than any other type of bridge and it is extremely efficient in terms of materials. Suspension bridges use steel cable under tension to hold up the roadbed. Cables supporting suspension bridges are made of individual strands capable of holding thousands of pounds.

Cantilever bridges are a type of truss bridge built toward the center of the river from each bank then joined in the middle. In Quebec, Canada, one of the world's longest cantilever bridge crosses the St. Lawrence River. A ***simple truss designed bridge*** serves well where a large amount of wood exists. Not only are wood bridges easy to build, they are capable of carrying heavy loads. The truss design is much stronger than simple designs where boards are laid across rivers. ***Steel truss bridges***, although not as capable of great spans as other bridge designs, can be quickly assembled and support heavy loads. Often railroads use this type of bridge. Trusses spread out the load to a large number of steel beams.

Three important components of a ***truss bridge*** are the **abutments,** which support the end of the bridge, **members**, which are the framework of the bridge trussm and **joints**, which connect members together and connect the bridge to the abutments.

The **external forces** on a bridge create two basic types of **internal forces** in the bridge members. These two internal forces are **tension** and **compression**. **Tension** forces try to pull things apart and **compression forces** try to crush things. In addition, compression forces also try to warp or buckle thing.

If a bridge member pulls apart, buckle or crush due to **overload**, the bridge will collapse. The bigger the bridge member, the stronger it is and the less chance of an overload.

Individual member failure is not the only reason a bridge can fail. The bridge might fail because it is **unstable**. There are two types of geometric instability in a truss bridge: First, a truss bridge will fall down if it is not made of triangles. These bridges are called **internally unstable**. Second, a truss bridge will fall down if both abutments do not support it. These bridges are called **externally unstable.**

Implementation Procedure

1.Divide the students into groups with 2 or 3 people per group. Give each group one piece of newspaper (or plain paper), 5 paper clips (or 5 inches of masking tape), one ruler, 2 books , 100 pennies (or a set amount of small weights). A bridge must support its own weight (the dead load), it should also support the weight of anything that moves on it (a live load). It's important that students understand the difference between a dead load and live load. Ask the students to build a paper bridge (http://www.pbs.org/wgbh/bildingbig/educator/act_paper_ho.html) with the materials that are available to them. The bridge must span 8" and hold 100 pennies. Make sure you tell students that they cannot tape the bridge to the books or countertops the space under the bridge must be clear to allow boats safely through the passage. Ask students to record how many pennies the bridge holds, where the bridge fails if it breaks, and how the bridge could be redesigned to hold more weight.

2. Explain to students that when engineers design a bridge they must consider the forces loads that will be placed on the bridge, while carefully choose the best material (http://www.pbs.org/wgbh/buildingbig/lab/materials.html) to construct the bridge. To understand the forces, (compression, tension, torsion, and shear) have students complete the mini activities (http://www.pbs.org/wgbh/buildingbig/educator/act_index.html) Force-ful Furniture, Name that Load, Feel the Pressure, Feel the Stretch, Sponge Beam and Human Arch.

3. Present the class with pictures or examples of the Golden Gate Bridge, Brooklyn Bridge, Iron Bridge and Firth of Forth (http://www.pbs.org/wgbh/buildingbig/bridge/index.html). Divide students in groups with two or three students per group. Using books, magazines or the Internet, ask the students to complete the research questions on the Bridge Research handout. Offer an after-school opportunity for students to come in for extra help so that they feel more comfortable using the computer or Internet. It is important for students not only to grasp an understanding of the technical facts about the bridge, but also to find out what impacts the bridge had on the surrounding communities and environment. At the end of the time, each group shares their finding with the class. Guide the students through a discussion on predicting what would have happen to the communities or the environment had the four bridges discussed had not been built. Ask the students these questions:

- Would the people have continued to live in the area if a bridge was not built? Why or why not?
- Would the companies/businesses whose success relied on the workers who commuted back and forth been as successful?
- What would have happened to the businesses?
- What would have happened to the residential communities?

4. Introduce the students to the concept that different types of bridges are built for different reasons. A lightweight bridge would not be built where there is a large load; the bridge would crumb under the pressure of the load. A suspension bridge would not be built for a short bridge span. Put the students into their original bridge research groups. Take the groups to the computer lab or allow students to rotate on a computer station with Internet access. Students are asked to assume the role as an engineer to help Craggy Rock in the Bridge Challenge (http://www.pbs.org/wgbh/buildingbig/bridge/challenge/index.html) With this activity, students are presented with scenarios and asked to choose a specific bridge type for a multi-lane bridge for commuters and tourists, a footbridge across a stream, a highway bridge across a busy shipping port and a railroad bridge in a national park. At the end of this activity students will have a strong grasp of the use of 4 types of bridges. Invite a local contractor/civil engineer to be a guest speaker.

5.Keep students in their original research groups. Give each student the United Bridge student handout. While students are investigating the situation, each group should record their findings on the Island Town Bridge Investigation Chart (Appendix C). Make sure that from the information given in the scenario students are able to identify the best solution for all the citizens involved. Students should consider what effects widening the bridge, building a new bridge, or not doing anything at all will have on the traffic congestion, resources, employment, environment for each of the four cities in the scenario.

6. After each group has finished investigating the impacts of whether to widen or rebuild the bridge, ask students to brainstorm what type of bridge should connect Island Town to the other towns. In groups, draw thumbnail sketches of possible solutions, choose one of the thumbnail sketches and begin drawing a final layout drawing. Each group then constructs their solution out of the material given to them (balsa wood, toothpicks, straws, and Popsicle sticks). After the construction of their bridges, each group prepares a presentation of their solution for the Town Meeting. The presentation should include explanations of why the type of bridge was chosen and the affects it will have on each of the towns involved.

7. Divide the students into 4 groups and assign each group the citizenship of Milesaway, Castaway, Hideaway or Island Town. Ask each group to formulate an opinion about how widening the bridge or having a new bridge built will affect their town regarding the traffic congestion, resources, employment, and environment. Students should record their ideas on the Area Town Meeting handouts. Each group of students conducts their presentation and presents their bridge model to the class. Students are encouraged to ask the presenters questions that relate to the affects on their town. After each group has conducted their presentation, conduct a vote on whose bridge proposal would best suit the interests and needs of all the towns involved. Invite the area City Planner to assume the role as the Highway Department Commissioner. If the guest is male, ask if he could bring a female coworker that assists him on projects. Creating the scenario of a town meeting gives the activity a human connection, the activity is no longer just about building a bridge. Display the bridge chosen by the class in a display case outside the technology education classroom.

Assessment

Some suggestions to check for learning:

- Can the students identify the difference between a dead load and a live load?
- Can the students explain the forces: compression, tension, torsion, and shear and give examples as to how each is applied to a bridge structure?
- Can the students explain why a bridge can be so important to a community or communities?
- Can the students explain why a bridge is shaped the way it is?

- Can the students identify at least two types of bridges?
- Can the students identify at least two types of materials used to build bridges and explain why that material is used?

Extension Learning Opportunities

- Ask the students to create a list of structures in their community and investigate a local "Wonder". Use the Educators Guide at http://www.pbs.org/wgbh/buildingbig/educator/act_index.html) to guide the students through the experience.

- Students could research reasons why bridge structures in Wisconsin are being rebuilt. Many of the designs are changing. What are the particular reasons for the changes? Are the structures old and becoming dangerous? Are the needs changing? Students could research the construction companies involved in the rebuilding process and find differences and similarities of bridge structure styles the construction industry tends to use and why.

Career Connections

Civil Engineer

Civil engineers design roads, airports, bridges, highways, skyscrapers, and many other types of structures. Their goal is to design systems and facilities that are functional, efficient, and long lasting. They are concerned with the environmental impact of their projects and study the environmental concerns of an area. They use this information to plan projects that are not harmful to the environment. Civil engineers must be aware of the many factors that also influence the long-term effectiveness of their projects. These concerns include population shifts, urban planning/renewal efforts, zoning laws, and building codes of the area where projects are planned.

REPRESENTATIVE OCCUPATION TITLES

1. Construction Engineer

- Designs bridges and buildings that will resist the forces of nature such as wind, temperature, and rainfall

2. Environmental Engineer

- Designs hazardous waste facilities that will minimize the impact of these materials on the environment

3. Geotechnical Engineer

   - Studies the properties of the soil and rock that will support the construction project

4. Structural Engineer

   - Supervises the construction of projects designed by other engineers

5. Transportation Engineer

   - Designs highways, railroads, and airports

6. Urban Planning Engineer

   - Designs streets, parks, industrial parks, and housing developments

   7. Water Resource Engineer

   - Designs structures that control water such as dams, pipelines, and aqueducts.

   Students interested in this occupation should take a college preparatory curriculum, which includes natural resource conservation, environmental conservation, computing, advanced programming, calculus, biology, chemistry, earth science, physics, drafting, and computer design and drafting. Wisconsin salaries range from 41,000 to 60,000

Comments, questions, or more information contact Courtney Reed Jenkins - 608-266-3551

Submit questions or comments about the Career & Technical Education webpage to: *Deb Motiff - Team Webmaster*

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The United Bridge

Recent studies show that many people are moving to the Island Town area, but are living in Castaway, Hideaway and Milesaway. The local highway department is starting to log a large number of complaints about the bridge that connects Highways 29 and 32 to Island Town. In the last 10 years there has been a 200% increase in the number of accidents where Highways 29 and 32 merge together.

There is a mall and a shopping center at the southern end of Island Town. Castaway has nothing but a convenience store, and Hideaway has a major chain grocery store.

Hideaway, Milesaway and Castaway are all rapidly growing communities. Milesaway is a rural community with many local ordinances such as each building lot has to be a minimum of ¾ acre. Hideaway is expanding into the surrounding farmland.

Design Challenge

Your firm has been hired to consult with the highway department in the Castaway, Hideaway, Milesaway and Island Town area. The firm has been asked to investigate 3 options, create a model of the solution and instead of the highway department, and present the solution to the citizens of Milesaway, Hideaway, Castaway and Island Town at a county meeting. The highway department has requested that your firm investigate the following three options and recommend which option is the best solution.

- Widening the bridge
- Building a new bridge beside the existing bridge
- Doing nothing at all

Before you investigate each option, create a list of three things that you think are important to consider when investigating each option. The highway department wants the citizens of each city to be happy with the recommended solution. Use the "Island Town Bridge" chart to record notes during the discussion with the members of your firm.

at Adobe's web site

Design Portfolio requirements:

- Short research paper on one of the four bridges discussed in class.
- A written explanation of the "Bridge Challenge" experience. Was it meaningful? What did you learn
- List the 3 things your firm considered important when investigating each of the option. Why are each of these important?
- Island Town Bridge chart.
- Thumbnail sketches of bridge solutions and final Layout drawing.
- Brief explanation of why the final solution was chosen.

Presentation

- Scale model of recommended solution
- An explanation of the effects of solution on each town that includes overall advantages and disadvantages

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The United Bridge for Island Town and Surrounding Area

In the chart below discuss how the towns people from Milesaway, Castaway, Hideaway and Island Town are effected by each scenario.

	Milesaway	Castaway	Hideaway	Island Town
Widening the bridge • Traffic congestion • Resources • Employment • Environment • Other • Advantages • Disadvantages				
Building a new bridge • Traffic congestion • Resources • Employment • Environment • Other. • Advantages • Disadvantages				
Not doing anything at all • Traffic congestion • Resources				

on their web browser to view pdf files. The Acrobat reader is available free at Adobe's web site	• Employment • Environment • Other • Advantages • Disadvantages				

Citizens of Milesaway – Area Town Meeting

Building a new bridge	Impacts
Traffic congestion	
Resources	
Employment	
Environment	
Other	
Advantages	
Disadvantages	

Remodeling existing	Impacts

bridge	
Traffic congestion	
Resources	
Employment	
Environment	
Other	
Advantages	
Disadvantages	

Citizens of Hideaway- Area Town Meeting

Building a new bridge	Impacts
Traffic congestion	
Resources	
Employment	
Environment	
Other	
Advantages	
Disadvantages	

Remodeling existing bridge	Impacts
Traffic congestion	
Resources	

Employment	
Environment	
Other	
Advantages	
Disadvantages	

Citizens of Castaway- Area Town Meeting

Building a new bridge	Impacts
Traffic congestion	
Resources	
Employment	
Environment	
Other	
Advantages	
Disadvantages	

Remodeling existing bridge	Impacts
Traffic congestion	
Resources	

Employment	
Environment	
Other	
Advantages	
Disadvantages	

Citizens of Island Town – Area Town Meeting

Building a new bridge	Impacts
Traffic congestion	
Resources	
Employment	
Environment	
Other	
Advantages	
Disadvantages	

Remodeling existing bridge	Impacts
Traffic congestion	
Resources	

Employment	
Environment	
Other	
Advantages	
Disadvantages	

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Resources: United Bridges

Women in Civil Engineering

http://civilengineer.about.com/cs/womencivileng/index.htm

Bridge Websites

Edmund Pettus Bridge- http://www.maintour.com/alabama/selma.htm

Battle of Stirling Bridge - http://www.geocities.com/CollegePark/Quad/7843/battles/brig.html

The Golden Gate Bridge - http://www.goldengate.org/

The Sydney Harbour Bridge - http://www.bridgeclimb.com.au/history_frs.htm

Sant'Angelo Bridge - http://www.dolcevita.com/events/bernini/bernini3.htm

Paris by the Water: The More Famous Bridges - http://www.pariswater.com/ponts/ponts.ht

The Civil Engineering Portal/Structural Engineering/ Bridge Engineering - http://www.icivilengineer.com/Structural_Engineering/Bridge_Engineering/Famous_Brid

Sio-Seh Pole - http://tehran.stanford.edu/imagemap/bridge.html

Great Bridges Facts and Photos http://www.architecture.about.com/cs/greatbridges

Emily Roebling – http://www.astr.ua.edu/4000WS/ROEBLING.html

http://eroosevelths.pgcps.pg.k12.md.us/~templin/engrweb/brokbridge.html

Brooklyn Bridge - http://www.greatbuildings.com/buildings/Brooklyn_Bridge.html

http://www.endex.com/gf/buildings/bbridge/bbridge.html

http://www.structurae.de/index_e.html?http://www.structurae.de/DataEnglish/str00011.htr

http://www.pbs.org/wgbh/buildingbig/wonder/structure/browse.html

http://www.howstuffworks.com/question322.htm

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Career Information Web Sites

http://stats.bls.gov/K12/html/edu_over.htm

http://gordonworks.com

http://www.library.ucsb.edu/subj/career.html/p>

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