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Curriculum Units by Fellows of the National Initiative
2008 Volume IV: Bridges: The Art and Science for Creating Community Connections

Terrific Ts- Truss, Triangle, Tangram and Technology Exploring Bridge Design with the Elementary Student

Curriculum Unit 08.04.06, published September 2008
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Introduction

An inspiring old English proverb states "let every man praise a bridge". In everyday use bridges are taken for granted, we expect them to make our paths of travel easy and efficient. Since early civilizations, bridges have played a significant role in linking communities and cultures.

Bridges affect everyday life in some of the most unique ways. The unique way that they affect us can be through environment, location and economics. They exist so that they can be used by us. Bridges can be created as well for aesthetic qualities. This can be for enhancement of the environment. As stated by Martin Gehner, Professor Emeritus of Architectural Engineering at Yale University, "Bridges like no other human artifact, better represents the human need for continuity, life and change." The bridge in itself makes our lives easier. For instance their, location is important in the fact that, the bridge, connects one community to another. The bridge makes crossing a river, terrain or mountain accessible to communities other wise separate. Another important factor is environment. When writing about environment several factors come into play namely weather patterns. The bridge has to with stand these conditions over a long period of time.

The climate imposes a significant effect on a bridge. The climate in my city changes seasonally, thus giving our bridges a break from one particular type of weather season over a long length of time. Another factor when bridges are built is economics. The economic condition of the place where the bridge is built is important to the community. The bridge makes traveling from one mall to another easier. The city depends on bridges to make significant connections between people within the larger region. It helps with the transportation of goods and material over rivers. Bridges make it easier for local resources to be imported and exported.

First of all a bridge is like the game tug of war where each team has equal weight. If each side is equal it will balance out. They are pulling and pushing but no side falls. That's how a bridge stays up. The bridge's members are either in compression or tension. This is the tug of war that is involved with the structure of the bridge. The members are built to keep the bridge in a balanced state. You can tell a bridge is a bridge because it has a deck, supports, a span and a foundation. These basic members comprise the whole bridge's structure. What has made the bridge of interest to me as a teacher is their total existence.

This unit will explore my hometown of Pittsburgh, Pennsylvania by looking at several truss bridges. While

looking at the truss bridges, I will be using computer interactive software games involving a tangram puzzle. In the tangram puzzle there are polygon shapes the square, triangle and parallelogram and in which the triangle is a major shape in the truss design. Trusses become efficient and strong structural systems through the use of triangular geometry of its members. The trusses that will be used in this unit are the steel trussed lattice type, the lenticular truss, and the steel arched form.

My city is in the north east and is often called the city of bridges. It has acquired this name because it has the most bridges per capita in the world. (Flying off the Bridge to Nowhere and other tales of Pittsburgh Bridges) (1993) we have hills, mountains and rivers so this topography lends to a community of bridges. Pittsburgh is unique in the fact that it has three self anchored suspension bridges; that are called sister bridges because they are right next to each other. The city is noted for great bridge companies such as American Bridge Corporation, which is currently repairing bridges across the country, and the G.W.G. Ferris and Company which inspected bridges in the 1800s. This later company was founded by George Washington Gale Ferris, Jr. George made one of the first steel bridges in America and also he invented and built the first Ferris wheel. His main focuses in both of his inventions were unique applications for tension, compression, load and capacity of structural systems. I will be looking at these concepts in the truss bridge. Andrew Carnegie an industrialist, made cast iron train bridges, Bessemer steel bridges and several museums are named after him here in Pittsburgh. The truss initially was made for the railroad, because of its capability to carry heavy loads. We will look at these pioneers in depth. Pioneers are inspiring models for creative young minds to study while exploring the four Ts. Pittsburgh and its many bridges will be a resource in researching the history of bridges.

The first T is the geometric shape *Triangle*. This is a polygon. This shape provides the basic stable geometry designing of a truss. Another important polygon is a square. This shape is initially used with a diagonal brace to create a stable form. This brace makes two triangles within the square and makes the weaker square into two strong triangles. In looking at the triangle I will discuss single forces that when added create an imposed load. In this instance I would like to research the math and science aspects related to bridge design related to forces.

The second T is *Tangram* used in combination with the third T *Technology*. A tangram originated in China. It involves polygons that are used in a puzzle. You make two- dimensional designs with this puzzle. The problem contains five triangles, one square and a parallelogram. This part of the unit is technology driven.

The puzzle is on software provided by the Public Broadcasting Company. It can be accessed at pbskids.org. The software provides an opportunity to design different figures and objects. Design is so important when making bridges. The bridge may become a wonderful picture as in the tangram. The tangram game will provide my students with methodical design making. This is a basic way of letting them experience some visual geometrical patterns of bridge design. They will put things together to create a bridge, and engage themselves in exploring how things fit together. In this part of the unit I will also discuss the designer/ architects Lindenthal and Ferris. Lindenthal designed the Smithfield Bridge and Ferris just happen to have invented the Ferris wheel which just happens to have triangles, and not only did he do that, he designed a bridge. Andrew Carnegie as well will be discussed because of his iron bridges for rail cars. I am including the iron bridges because of their importance with the design of the truss. The designing engineer must consider several factors when designing a bridge. They consider the distance to be crossed and the community within which it will be located. These considerations and the history of Pittsburgh will help with the development of this unit. In this section of the unit my students will do journal drawings of bridges. This will help them with the visual application of bridge making.

The *Truss* is the fourth T. I choose the truss bridge because of its simple design. Trusses are created by fastening structural elements together to form triangles. It has so many great scientific principles related to support, strength and capacity. The simple truss is an endangered bridge. I will use the truss to discuss bridges in general. Truss bridges have strong frames that support many other bridges such as the arch, beam and cantilever over its span. The framework distributes the load. They can carry heavy loads and are economical to build. Some of the other bridge types incorporate the truss principles.

I will look at the purpose of a bridge and why it is so important to transportation and a

community. As a cumulative activity we will be taking a field trip to all of the bridges in this unit. So in writing about the four Ts, I will be looking at mathematics, sciences, visual arts and history using variety of stories to motivate and arouse the student's interest.

Objectives

In this section of the paper the objectives will be related to what the student will be expected to learn from this unit. Let's begin with the mathematics. This unit will deal with geometry and form. The identification of shapes and size will be important because as we explore the tangram puzzle where the shapes of the triangles are different sizes. The truss design has different shapes involved as well as size. We will also identify common two and three dimensional shapes. In my current curriculum flat and solid shapes are studied. In this chapter, the students look at shapes in the environment and manipulate shapes through models that involve a sphere, cone, cylinder or cube. The two dimensional shapes are flat shapes and the three dimensional are the solid shapes. We will create geometric designs by the use of the computer software and the drawing of their bridges in the journaling part of the unit.

Other flat shape models are available as well. We also have to understand spatial concepts and their relationship to people's experiences of space. Spatial relationships are important in relation to a bridge. For my students this concept has to be understood by examples. Symmetry will be explored due to the nature of the truss design. This concept is part of our regular curriculum and the truss design gives another way of looking at it. The visual art objectives will be to use elements of line, shape and texture through drawing. Students will draw or paint bridges. When we discuss the bridges a picture will be shown through a photo or story. In response to that image the student will create a collection of drawings. An objective that will apply to this process is pictorial representation. The elementary student is just beginning the writing process, so the picture will be included along with one or two sentences as part of the journal. Also under the writing objectives, technology is listed as a form of information. Since I am currently talking about technology, I would like to explore some of those objectives. Let's look at those objectives. We will have to know basic computer knowledge such as the mouse is a part of the computer. The tangram game requires you to drag the mouse to put the tangram shapes into a puzzle. Although my students are daily on the computer for a reading program, they will already be exposed to technology. This program enhances their technology literacy. Also, they will be able to explain steps in constructing something. The construction is the use of the puzzles and other activities in the unit.

A science objective is to demonstrate and understand the process of scientific inquiry by participating in scientific investigations and working collaboratively. Achieving

this objective will be on going as we investigate bridges and study what makes a bridge what it is. The history part of this unit will look at the physical characteristics of place and region. The places will be seen through the photographs previously mentioned with the addition of a field trip. The students will begin to understand that people work together in a process for creating and building bridges. This will be recognized through the explanation of jobs and how the workers design and build a bridge. We will begin to develop an understanding of historical interpretation. As some bridges are identified historically, a timeline will be drawn about different truss bridges. This experience will give the students a sense of time and events. We will also identify important individuals that contributed to United States history, including the architects, company owners and contractors who have contributed to the history of bridges.

Strategies

The strategy that I will use to ensure comprehension will involve Blooms Taxonomy, which has five specific skills that will be used throughout this unit. They are application, comprehension, knowledge, analysis, synthesis and evaluation. These levels of Cognitive skills will be utilized in the effort to help my students understand bridge design. While discussing the content I will discuss all five strategies. Starting with bridges in general, we will review some basic bridge requirements. There are two phases in building a bridge. The first phase is the planning phase. People from the community together with experts in bridge planning will review all criteria for creating a bridge. Surveyors will take measurements of the terrain and map out the site's topography. Next there is the bridge designer who is in charge of the project. The architect helps the designer and makes sure it will be aesthetically pleasing. The soil engineer drills the holes to get samples of the soil. The aerial photographer takes pictures from above. This helps the surveyor. The traffic and safety expert look at traffic issues related to safety. The environmentalist makes sure the wildlife and wetlands are not disturbed.

The second phase of bridge building is the building phase where the structural engineer approves the design and the contractor bids on it. The approval of the design can be very simple in design or complicated. Simple by being just a beam bridge or could be a unique and artistic bridge. The bidding is when you want to select a company to make the bridge. The inspector comes to the bridge site to report any problems. This for safety of the bridge. The contractor is in charge of building a bridge. This is the person or company who agreed to build the bridge He or She assigns a superintendent who orders all of the material to make the bridge. Then they give the jobs to foremen to be in charge of specific jobs. Those jobs can be steel workers or seeing over the masonry. Masonry is the stone or brick work. The very important people are the workers. They construct the bridge. These are the people that work together to make a bridge exist. They put the bridge together. I plan to introduce bridges by talking about the jobs and giving out jobs in the classroom. I want to make four different teams that will complete a task. I will achieve this through giving out building blocks and have each the teams design a bridge. This will be done in lesson three. This will begin with giving them an idea and experience that making a bridge is a team effort. I will now look the four Ts in respect to the strategies and how they will be applied.

Truss

The first T will be the truss. The history of trusses will be presented as it relates to the making of bridges. The earliest trusses were made of wood. The Greeks made trusses for their dwellings. In 1570 Andrea Palladio

published I Quattro Libri dell'Architettura which contained instructions for wooden trussed bridges. The truss bridge was made in the form of a wood trestle. When the railroad came along strong bridges were designed and the truss design evolved after many trail and errors. There are several types of truss bridges. What makes the truss work is that the vertical and diagonal members work together to distribute the forces (compression and tension). This is this tug of war game I spoke about in my introduction. You may think of compression as being squeezed and tension stretching like a rubber band. The top part of a truss is in compression and the bottom is tension. The truss is made up of triangles. The triangles distribute the load and transfer it to the supports. Triangles are used in trussed bridges to add strength and stability. To see some examples of a truss go to www.matsuo-bridge.co.jp/english/bridges/basic/truss.shtm

The five Blooms Taxonomy strategies are:

* Knowledge

* Comprehension

* Application

* Analysis

* Synthesis

* Evaluation

The strategies will use verbs to describe the six skills listed above such as recall, manipulate, demonstrate, discuss or choose. The poster that will accompany this unit is back in the appendix A. Benjamin Bloom an educational psychologist divided educational objectives into three domains. They are affective, psychomotor and cognitive. We will deal with the cognitive domain. This domain is considered to be learning in action, because it is based on verbs. A verb in its grammatical context is a word that shows action.

To look at the five strategies that will apply to learning about the truss I will use a verb to describe the specific action that will be taken. Under the domain of knowledge I will have the students recall the different types of trusses. We will make a Warren truss with Popsicle sticks. We will also list other truss types in our vocabulary. The comprehension factor of trusses relates to an identification of a truss. This skill can also be accomplished by acting like a truss in a group setting. The next strategy is application. The students will use their journals to draw trusses. The journal will help with interpreting the structure visually. I would like to start with the Warren truss. They will also make puzzles of a truss. We will make an analysis through comparing different bridges and distinguish between different trussed bridges by their name. Synthesis will take place when we take our field trip to visit several different bridges. We will compare and design our own bridges by use of the photo essay. Evaluation will be through identifying some of the important parts of a bridge

Truss/ History

The history of three bridges in Pittsburgh will be presented and explained. These bridges are from the truss family and are historical artifacts. I will use the history as way of building a foundation for the unit. Pittsburgh bridges are very important due to the three rivers. Pittsburgh is composed of small communities in which the bridges connect them. The city of Pittsburgh claims to have 944 bridges and 59 rivers Three primary rivers, the Monongahela, the Allegheny, and the Ohio intersect and create a land section called Point Park. These rivers flow through and connect the communities together. Pittsburgh's first river bridges were made of wood

and they have long since been replaced. Most bridges were built from 1924-1940. Some of the building of highways triggered more construction of bridges. The second half of the century resulted in more than one hundred bridges being built. The building of bridges is important to Pittsburgh as well. Pittsburgh is known for its bridge companies dating back to the early 1800s. Several important industrialists and designers had their companies in the city. Andrew Carnegie owned the Keystone Company which later became the US Steel Company. This company help builds all of the bridges around America. In the 1800s George Ferris own a company in this city named The G.W.G Ferris Company. They inspected the bridges and made parts for bridges. The American Bridge Company is currently fixing bridges across the country. These companies tell the rich history of Pittsburgh and how it relates to bridges. The first bridge I will look at is the Smithfield Street Bridge. The image of it:

(Wikipedia 2003) This Bridge is designed in the style of a steel lenticular truss. It has some wrought iron members. It crosses the Monongahela River and has a pedestrian walkway on both sides. The first bridge erected at this site in 1818 was a wooden covered bridge. It was the first river crossing bridge in Pittsburgh. The wooden bridge was destroyed by fire in 1845. The designer for the replacement bridge was Gustav Lindenthal built in1881-1883. He worked for the Keystone Company. This bridge was restored three times. John Roebling was the engineer who was in charge of restoring the original design. It was restored again in 1985 to the Lindenthal original design. It is the oldest river bridge in Allegheny County. This bridge is one of the oldest truss bridges in the United States and has the longest span for its type. One of its many awards is the United States National Historical Civil Engineering Landmark and it has received many local and national rewards.

The second bridge is a combination bridge. The Sixteenth Street Bridge crosses over the Allegheny River. It is a steel trussed arch with a suspended deck. The original covered wood bridge at this location was destroyed by fire in 1919. The current bridge was built in1923, ornamented with bronze structures. Architects Warren and Wetmore designed it. Pedestrian walkways with two way traffic lanes are included in the design of this bridge. The Pittsburgh Arts commission was heavily involved in the design process because they wanted more artistic involvement with the designing of the bridges.

The third bridge is the McKee's Rock Bridge. It crosses over the Ohio River. This bridge is a steel trussed arch. This bridge stretches one and half miles. It is multi structured and was built in the early 1900s. Now the

students will look at these bridges through the strategies in blooms taxonomy when giving the history of the bridges. Knowledge will be experienced through naming the three bridges as well as recalling the types of bridges. The students will show comprehension through describing the bridges as they put it into their own words. We can also compare the differences of the bridges. The application part will take place as the students draw illustrations of the bridges. At the field trip to visit the bridges the students can relate to experiencing the bridge by walking under them and driving over them. As we walk under the McKee's Rocks Bridge, we will explore its structural design. They will get the chance to see the truss design up close. Walking on this bridge will show the lattice design in the arch. The analysis will also take place during the field trip to the bridges. We will get a chance to distinguish between the three bridges. The synthesis will be through designing their own bridges and doing a skit using all of the jobs that were named to construct a bridge. This is the skill of schematizing bridge design through role playing. The evaluation process will be through the choosing of a bridge that they like out of the three and do a painting of it. The painting w ill be labeled by the students and put on a rubric.

Triangle

The triangle is a polygon, because all of its sides have straight lines. It has three corners and three sides the type of triangle I am talking about is equilateral. The angles of a triangle add up to one hundred and eighty degrees. It is one of the geometric shapes. All triangles are two dimensional. It is studied in geometry. Geometry is the study of property and relationships of points, lines, angles surfaces and solids. Some important facts about triangles, they have three sides. They have three points, corners or angles. All three sides connect and are straight. A triangle is a rigid strong shape because of its stability. The triangles make up the truss design. They are in an assembly of triangles made from a series of straight bars. The triangle is used because of its strength and stability. The truss is also identified by the shapes of the triangle in its design. The extremely strong triangle is the only geometric form that can not be bent out of shape. From as far back as ancient times the triangle has been held in high esteem. For the Egyptian, they were very sacred in the form of the pyramids. The pyramid has four triangles as sides and a square base. A modern extension of the triangle and the pyramid is the geodesic dome which combines triangles and pyramids. To get ready for this lesson I will read The Shape of Things.

The first strategy is knowledge. The students will recognize a triangle and distinguish it from other shapes. This will be through identifying it among other shapes. While drawing some of the pictures, they will be able to use the triangle. The comprehension will take place when comparing them to other shapes while doing a puzzle and completing a truss making exercise. The truss bridge will help with comprehending what this shape looks like. Application will be when the Popsicle triangles will be made. The students will be using triangles to make this type of bridge. The analysis will come when the distinguishing of the shape will be done. This will also be evident through when they do the actual making of the triangles. The triangle has equal sides and that has to be understood. One of the characteristics that make it so unique is the equal sides. They will create designs using triangles. They will label their shape. How the student will be using evaluation of the knowledge of a triangle is through choosing the correct form to make triangles. To further explore the strength of a triangle you must remember that two dimensional shapes are flat. I would hope to build a tetrahedron. A regular tetrahedron is a three dimensional form created by four equilateral triangles with all edges connected. It is just a four sided triangle. Each will build one and take it home. Also a learning center will be set up to let the students' build three dimensional objects from flat shapes.

Tangram/ Technology

The tangram is a puzzle that dates back to the early 1800s. This game in China was considered to be a game for women and children. It comes from the Song Dynasty. According to Chinese history it was part of their furniture. Originally it had six triangular tables and later added rectangular one. After the Ming Dynasty the objects used became wooden blocks. The legend is said that a servant of the emperor was carrying a very expensive tile and tripped and shattered the tile. The servant panicked and tried to put it back together in a square. Instead he created thousands of pictures and patterns as he tried. Tangram is an English word meaning puzzle or trinket. The word was first used by Thomas Hill a former president of Harvard in his book "Geometrical Puzzle for the Youth" in 1848. Tangrams were popular in the 19th century. Some tangrams were made with ivory or jade. The puzzle is composed of five right angle triangles, a square, and a parallelogram. (The parallelogram is unique because any way you turn the puzzles image can not be done through rotation but only through flipping over.)The seven shapes are called tans. They fit together to form a new shape. The shapes make interesting designs. The geometrical design provides mathematical relationships and forms. The tangram is important to this unit for three major reasons with the emphasis on the use of triangles. The tangram designing emphasis of objects and the way in which they will be used in throughout the unit will bring the technological use into focus. The tangram and technology is a combination of both the third and fourth T. The game that I will be using in this unit is called Sagwa. It is Chinese oriented and it is a piece of soft ware that is interactive software can be accessed at http://pbskids.org/sagwa/games/tangrams/index.html the students will learn the basics about how to use a computer.

This game designs objects and is self correcting. It is based on the story about the Chinese Cat .The game is from CineGroupe Sagwa Inc. The objects of the game are a cat or a storyteller and others. When the puzzle is completed there is praise. A hint button can be pushed to help with completing the puzzle. There are two levels for different levels of student's abilities. How I plan to apply the strategies in blooms taxonomy is knowledge. The students before going onto the game will cut out their individual pieces and make there own tangram puzzle. They will do this activity and have enough time to manipulate and become familiar with making images with the puzzle. They will recognize the shapes and use them for designing. A student's comprehension will be tested when the Grandfather Tang's story is read. The students will answer questions concerning the story and how the tangram was used to tell the story. Application will be through manipulating the tangram into some of the things that are in the story. Analysis will take place when they choose puzzle pieces to create designs. They will contrast and fit different triangle shapes together. The synthesis will be through discussion of the history of tangrams the story and how the puzzles are used. Their designing of the objects will show their level of understanding how to use tangrams. Evaluation will be through the successful use of the software. Technology in the classroom helps keep the students up with the current sciences that are happening around the world. In this unit the technology will be used as a tool to support the task of designing and making decisions. In part, the unit the teacher's role turns to being a facilitator and providing guidance as needed. The whole game offers a process of learning through experimentation.

Bridge Time Line

The first book on bridge design was written in 1716 by Hubert Gautier. This is an account of how bridges evolved and arrived. The first bridge was made by a single log or by a wooden plank. The early bridges could not carry heavy weight. In China, one of the first low arch bridges in the world is the Zhoa Xian built in 610. Some arch bridges date back to the second century. A suspension bridge can be a simple rope type structure. The Inca used this type of bridge. The Menai Straits Bridge was built in1826. This suspension bridge was made of cables and iron chains. Akashi Kaikyo Bridge is the longest suspension bridge that was recently built in 1998. It connects the two islands of the Shikoku and the Honshu in Japan. In 1883 the Brooklyn Bridge was completed. It is the first suspension bridge with steel cables in the United States. The world's first steel bridge

was completed in Scotland in 1890. It was called the Forth Rail Bridge. The industrial revolution brought along the wrought iron truss design. There are six types of bridges beam, cantilever, arch, suspension, cable stayed and truss. A fine example of a cable stayed bridge is the Pont de Normandie. The Fourth Bridge in Scotland is a cantilever bridge. The Astoria Bridge in Oregon is a truss bridge. Beam bridges are the typical bridges that we see on many highways. Pictures of these bridges will be available. These pictures will assist with the drawing portion of the portfolio.

Classroom Activities

Lesson One

Introduction to Bridges

This lesson is an introduction to the subject of bridges. I will read the story the Three Billy Goat Gruff. Ask questions about the story. Relate the story to what was the main idea of the story. Discuss about the size of the goats. Then look at the reading patterns and do shared reading and have the students say the repetitive phrase. "Who's that trapping over my bridge"? Then have them role play the story. After the students have digested the story let them use building material to build bridges. This can be done with blocks legos, k-nex and other manipulative for building. The extension to this lesson will be asking them to draw a picture of a bridge. Using the overhead have the students look at bridges. Then using blue print paper have the students watched you model the correct techniques for drawing a picture. Architects use blueprint to show exactly how they want the bridge to be built. After they do the drawing let them use the blueprint during free time to build their bridges. A discussion will be generated about portfolio journals and the purpose will be restated, and that the rubric is an evaluation tool for the students. The rubric can be found in appendix C.

Lesson Two

Building a Truss Bridge

The students will make a basic truss design using Popsicle sticks. Have the students complete a KWL chart about bridges. Do the chart based on only student information. This chart is in three parts the K- what I know W- what I want to know L- what I learned. An example of the KWL Chart is in appendix D.A Warren truss is one of the basic truss structures that you can see in most bridges. This truss has several vertical and horizontal lines making a triangle design within a square. I will read the story The Adventures of the Beautiful Princess in Triangle Land. The triangle will be emphasized while reading this story. The shape will be identified and every time an illustration in the story has a triangle a discussion about the setting and context will be facilitated. An example of the Warren truss design bridge will be done so that it is visible for the students to see. As the students are gluing their Popsicle sticks, tell a little story about the bridge. After the individual bridges are completed we will glue them together to make two bridges.

Story

As you travel with your family and friends to the store or on vacation you will cross over many things roads hills valleys and bridges. Bridges are like streets they just cross over something that is in the way. They hold cars, people and their own weight. They hold themselves up by using compression and tension. This is like a

game of tug of war. (Students may ask about this game take advantage of this teachable moment and let them role play this) Explain that the forms of material used in building a bridge acts in this manner. Compression is a force that squeezes objects (pushes) together. Tension is a force that stretches (pulls). This forms of material that are used create this pushing and pulling that keeps the bridge from falling. Such as in the tug of war if someone pulls too much or pushes to much one side will fall so each side helps the other side hold up. The type of bridge we are making is a truss. The truss supports a system of beams which form the road deck to carry cars and vehicles.

Lesson Three

Building a Bridge- Team Work

This lesson will incorporate the specific jobs that come into play when building a bridge. Some of the specific jobs are architect, contractor, foreman and inspector. This lesson will consist of a structural engineer, inspector, contractor and foremen. The superintendent's job will be done by the teacher. The jobs were defined in the overview. After a brief discussion about building bridges. The discussion will focus on the first phase of building a bridge. Those important people are named in the overview. Read Popular Mechanics for kids- How do they build bridges? Then proceed with the jobs explaining what they do. This lesson is a cooperative lesson and those qualities will be emphasized. There will be one person for all the jobs except for the foremen there will be four people in four groups of foremen. Each foremen group will be titled by the material that they will be using, such as K-nex or Legos. There will be four types of building materials. The four groups will be taught ways to work as a team. The main collaborations are to work toward the group's goal. They will display a respectful attitude toward each member's ideas and needs as they develop in the group. They should be willingly helping each other through the building of the bridge. Each member will contribute to the building of the bridge by adding material. They should value each member of the group's opinion. To be willing to change your idea, if any member wants to change.

This collaboration is important because making a bridge is a collaborative effort every member is important to the building of a bridge. After they have built their bridges they may also stay up for open house or a bridge tea party with faculty and parents.

Bibliography/ Resources

Teacher List

Brown, David J. *Bridges: Three Thousand Years of Defying Nature*. Toronto: Firefly Books, 2005.

This book discusses the structure and form of bridges over time. A history of the development of bridges is given and helps the reader understand their existence.

Cortright, Robert S. *Bridging: Discovering the Beauty of Bridges*. Orergon: Bridge Ink, 1998.

The book provides the visual application of bridges. Different types of bridges throughout the world are photographed.

Gottemoeller, Frederick. *Bridgescape: The Art of Designing Bridges, Second Edition*. New York, NY: Wiley, 2004.

This book is on book on bridge designing that relates the designs to the environmental context. An engineer's perspective is given on bridge making.

Graf, Bernhard. *Bridges That Changed the World*. Fort Worth: Prestel Publishing, 2005.

Discussions on bridge types are written to illustrate how they affect the environment and community. The community and neighbourhoods are discussed based on the pros and cons of bridges related to these variables.

Irvin, Barbara Bando. *Geometry and fractions with tangrams: Grades 3-6*. Vernon hills: Learning Resources, Inc, 1995.

How does one relate geometry and math in depth to the tangram puzzle? This book offers activities and suggestions.

Kappraff, Jay. *Connections: The Geometric Bridge between Art and Science*. Sassari: World Scientific Publishing Company, 2002.

This book was chosen as a reference book on introduction to shapes in its environment. The aesthetic look at how shapes in the arts and sciences are related.

Kidney, Walter C. *Pittsburgh's Bridges: Architecture and Engineering*. Pittsburgh: Pittsburgh History &, 1999.

This book is about the history of Pittsburgh bridges and how they helped the communities where they are located. The different types of bridge design are noted.

Mainstone, Rowland. *Developments in Structural Form*. London: Architectural Press, 2001.

This book describes different structure forms and how they work. He looks at how the material affects the structure.

Regan, Bob. *Bridges of Pittsburgh*. Pittsburgh: Local History Co., 2006.

This is a photo essay and account of the bridges in this city. It talks of a small amount of history related to the bridges of this region.

Tzonis, Alexander. *Santiago Calatrava: Complete Works, Expanded Edition*. New York: Rizzoli, 2007.

This book discusses the Santiago's work and how he derived concepts for creating structures. The pictures are colourful and detailed.

Tzonis, Alexander. *Santiago Calatrava: The Poetics of Movement (Universe Architecture Series)*. New York: Universe Publishing, 1999.

This book is an interconnected book of his works related to art, movement and engineering. This book also has wonderful pictures of his work.

Whitney, Charles S. *Bridges of the World: Their Design and Construction*. New York: Dover Publications, 2003.

This is an interesting book in the fact that the way it illustrates how building materials have related to the evolution of building structures.

Classroom List

Burns, Margaret *The Greedy Triangle.* Pheonix. Scholastic Publishing 1995.

Since this book has a great adventure for you. The triangle takes the foreground with wanting to be more important than the other shapes in the story.

Foster, Dr. T. E. *The Tangram ABC Book*. New York: BookSurge Publishing, 2006.

This book uses the puzzle to teach the letters of the alphabet.

Foster, Dr. T. E. *Then and Now On Old MacDonald's Farm: A Tangram Number Book*. New York: BookSurge Publishing, 2006.

A very clever way of telling the story of Old Mac Donald had a farm. This book is a very artistic and mathematically integrated book.

Hartswick, F. Gregory. *The adventures of the beautiful princess in Triangle land, (His First tangram book)*. New York, NY: Simon & Schuster, 1925.

The play on the shape of a triangle and how all of the shapes to the puzzle come about.

Johmann, Carol A., and Elizabeth Rieth. *Bridges: Amazing Structures to Design, Build & Test (Kaleidoscope Kids)*. Charlotte: Williamson Publishing Company, 2005.

This is a book for students to learn about the scientific aspects of bridge building.

Johnston, Susan. *Tangrams ABC Kit*. New York: Dover Publications, 1979.

This is another way of teaching initial letter identification using this puzzle. The math impact is always there because of the tangram puzzle and its shapes.

Mackall, Dandi Daley. *The Shape of Things (Imagination Series) (Imagination Series)*. Minneapolis: Augsburg Fortress Publishers, 2003.

A look at the different shapes , a visual perception play on shapes and different settings.

Mechanics, Popular. *Popular Mechanics for Kids: How do they Build Bridges?* New York: Anchor Bay Entertainment, 1996.

This book shows kids how to build bridges on an elementary level. The use of inexpensive material is used.

Paterson, Katherine. *Bridge to Terabithia*. New York: HarperTrophy, 2005.

This is a chapter book and is a fantasy with different playful characters. The story is about boy and a girl escaping their daily life styles.

Shiotsu, Vicky. *Grandfather Tang's story (Multicultural series)*. Palos Verdes Estates: Frank Schaffer Publications, 1993.

A story that reflects the culture of the Chinese people and discusses the tangram in relation to telling the story.

Stevens, Janet. *The Three Billy Goats Gruff*. New York: Harcourt Big Books, 1995.

A classic folktale that captures repetitive phrasing and emphasizes the importance of the bridge to the troll.

Website List

Tan, Amy. *Tangram- Based on Book The Chinese Siamese cat* (1994)

-http://ppskids.org/sagwa/games/tangrams/index.html

This website will get you to the tangram interactive game. The game is part of this units tangram and technology feature. The game provides different levels of readiness. There are different objects that the tangram puzzle goes into. (Accessed April15, 2008).

Matsuo Bridge Company Ltd. *Types of Bridges.* (1999). www.matsuo-bridge.co.iplenglish/bridges/basics/truss.shtm

This site gives a definition for a truss design and also has the structure. A small writing about the truss bridge but kept very simple and a to the point example. (Accessed June10, 2008)

Classroom Material

25-Geoboards

2 sets of K-nex

1 set legos

5 packs multi-color construction paper

3- Classroom table top computers

25- scissors

25 water paint

25 boxes crayons

25 pencils

60 sheets of blueprint paper

1 overhead projector

3 tangram wooden puzzles (large)

15 pictures of bridges (truss (beam) suspension and cable also Pittsburgh bridges)

25 sets solid shapes

25 sets flat shapes

Resource

Appendix A

Table of Verbs

1 Knowledge	2 Comprehension	3 Application

list name	summarize	solve
identify	explain	illustrate
show	put into your own words	calculate
define	interpret	use
recognize	describe	interpret
recall	compare	relate
state	paraphrase	manipulate
	differentiate	apply
	demonstrate	classify
	visualize	modify
	find more information about	put into practice
	restate	
4 Analysis	5 Synthesis	6 Evaluation
analyze	design	evaluate
organize	hypothesize	choose
deduce	support	estimate
choose	schematize	judge
contrast	write	defend
compare	report	criticize
distinguish	discuss	justify
	plan	
	devise	
	compare	
	create	
	construct	

Example-Student will organize the puzzle.

Example-Student will design a bridge through a drawing.

Appendix B

Example- Student will discuss the story

Vocabulary

Abutment- A support at the end of a bridge.

Anchor- Places were suspension bridge cables are attached to the ground.

Centering- A wooden arch constructed as formwork to support the blocks of an arch bridge until the arch is complete.

Compression- An object that is pressed on both ends.

Deck- The roadway of a bridge.

Duct- A long narrow conduit along which wires or cables is threaded.

Foundation- The supports of a bridge that spreads the weight of the bridge into the ground.

Hanger- A cable or rod on which the deck of a suspension or arch bridge hangs.

Lattice girder- A steel or iron beam that has a built-up chord along its top and bottom edges, linked by a

crisscross pattern of struts and ties.

Masonry- Stone, brick or concrete.

Pier- A support that holds a bridge from underneath its deck. They are away from the abutments.

Span- The distance from one support to the next. The distance between the abutments or towers.

Strut- A part of a truss that gets pushed at both ends, so it is in compression when atruss has a load on it.

Tension- An object that is pulled at both ends is in tension.

Tie- A part of a truss that gets pulled at both ends so it is in tension, when the truss has a load on it.

Truss- A strong framework of straight sections of metal (struts and ties) joined together at their ends.

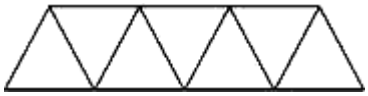
Truss girder- A truss that acts as a beam in a bridge.

Viaduct- A long bridge supported by many piers or arches that crosses a wide valley.

Weld- A way of joining two pieces of metal by melting the edges so they fuse together.

Appendix C

Bridge Rubric



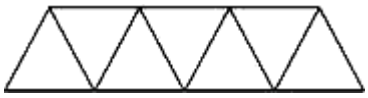
4 I can tell you my illustration (picture). Written words are seen. I have done my best work.

3 Retells the illustration (picture) with very little prompting. Written words are able to be seen. I have done my best work.

2 Tells the illustration with prompts. Some words are present.

1 My work is not my best work. Student needs several prompts to tell illustration (picture).

Bridge Self-Checklist



Did I put my words on my picture?

Yes No

Did I use an illustration (picture) and know what it was?

Yes No

Did I do my best and neat work?

Yes No

Appendix D

KWL Chart

What I Know	What I want to Know	What I Learned

Appendix E

Pennsylvania Kindergarten Standards- http://pde.state.pa.us/early_childhood/lib/

early_childhood/ October_2006_KINDERGARTEN_STANDARDS.pdf

1.3- Reading, Analyzing and Interpreting literature

Understand and respond to a variety of literacy selection that are read listened to or viewed.

1.4 Types of Writing

Use pictures and drawings to represent an idea

1.6 Speaking and Listening

Listen and discuss a story.

2.9 Geometry

Identify common two and three dimensional shapes

2.10 Trigonometry

Identify triangles in the environment and discuss how they are alike and different.

3.1 Unifying a Theme

Describe and identify what parts make up a whole.

3.2 Inquiry and Design

Develop the scientific method of inquiry.

8.1 Historical Analysis

Develop a concept of history.