Assignment Discovery Online Curriculum

Lesson title:
Tunnels: Underground Marvels

Grade level:
6-8

Subject area:
Technology

Duration:
Two or three class periods

Objectives:
Students will
1. understand some of the technology involved in constructing tunnels under cities, through mountains, and under water; and
2. examine some notable tunnels that have been constructed over time.

Materials:
The class will need the following:
- Computers with Internet access (optional but very helpful)

Each group will need the following:
- Approximately 50 blank index cards
- Pens and pencils
- Scrap paper

Each student will need the following:
- Pens and pencils
- One copy of Take-Home Activity Sheet: Design a Tunnel of the Future

The teacher will also need the following:
- One copy of Tunnels Fact Sheet

This lesson plan can be enhanced by purchasing the documentary *Tunnels: Underground Connectors* from our School Store. The documentary will air on Discovery February 14, March 21, April 25, and May 30, 2001.

Procedures:

1. Begin the activity by asking students what they know about tunnels. For example, ask them if they know where tunnels are usually built and how they are constructed. Then ask students if they can name any tunnels.

2. Divide the class into four teams of six or seven students. Tell students that their assignment is to create a class quiz game that focuses on tunnels. Give each group one of the following categories:
   - History of tunnels
   - Tools and techniques used to build tunnels
   - Notable tunnels
   - New tunnel technology

3. Each group should develop 10 questions in its category. Each game will consist of five questions in each category, worth 100, 200, 300, 400, and 500 points. Have students develop a range of answers, based on easy to difficult questions, and assign a number value to each. (Of their 10 questions, 2 should be worth 100 points, 2 worth 200 points, and so on.) Answers can be prepared in response to a multiple-choice format, true/false questions, or simple questions requiring a short answer.

4. For your information, the Fact Sheet includes some interesting points about each category that you can use to help students start their research. To supplement this information, students can use encyclopedias, books, and other reference materials, as well as the suggested Web sites.

5. After students have completed their answers, play two rounds of the quiz game. One student can be the moderator, another can be the scorekeeper, and three students can be contestants. As the contestants pick categories, the moderator should call on a student from the appropriate team to give the answer. Give each group of three students a chance to respond to five answers. Then select new contestants and a new moderator and scorekeeper. If possible, play the game until everyone has had a chance to be a contestant. Students with the three highest scores win the game.

6. Assign the Take-Home Sheet: The Future of Tunnel Construction for homework. Have students bring their sheets to class and share their ideas.

General Web Sites about Tunnels

These Web sites provide general information about tunnels. Students should probably begin their research here.

Discovery: Buildings, Bridges, and Tunnels
http://www.discovery.com/stories/technology/buildings/tunnels.html

All About Tunnels
http://www.pbs.org/wgbh/buildingbig/tunnel/index.html

These Web sites provide information about specific tunnels. These Web sites would be useful for students' research on notable tunnels.

Some Notable Tunnels
http://www.comptons.com/encyclopedia/TABLES/150995276_T.html

Central Artery/Tunnel Project (Big Dig)—Boston
http://www.bigdig.com/
http://www.pbs.org/wgbh/buildingbig/wonder/structure/central_artery.html

Channel Tunnel (Chunnel)—England and France
http://www.raileurope.com/us/rail/eurostar/channel_tunnel.htm
http://www.pbs.org/wgbh/buildingbig/wonder/structure/channel.html

Chesapeake Bay Bridge-Tunnel—Virginia
http://www.cbbt.com/
http://www.pbs.org/wgbh/buildingbig/wonder/structure/chesapeake_bay_tun.html

Seikan Tunnel—Japan
http://www.pref.aomori.jp/newline/sin-e08.html
http://www.pbs.org/wgbh/buildingbig/wonder/structure/seikan.html

Hoosac Tunnel—Massachusetts
http://www.intac.com/~jsumberg/hoosac.htm
http://www.pbs.org/wgbh/buildingbig/wonder/structure/hoosac.html

Holland Tunnel—New York-New Jersey
http://www.panynj.gov/tbt/htframe.HTM

Adaptation for older students:
Have high school students research a current tunnel project underway somewhere in the world. Then they should write a paper about where, how, and why it is being built. They should include information about unusual or new materials or design. Students can learn about current tunnel projects by country at the following Web site:
http://www.tunnelbuilder.com/projsearch_index.htm

Questions:

1. Where are tunnels usually constructed? Think of different types of tunnels, such as those under water, under land, or through a mountain. Why are such tunnels constructed? What benefits do they serve?

2. Why do major tunnel projects take so many years to complete?

3. What are some of the challenges involved in trying to dig through a mountain using a tunnel boring machine (TBM)?

4. Research a tunnel located in your area. Try to find out the estimated number of cars and trucks that pass through it each day.

5. What health hazards do tunnel construction workers face?

6. What precautions can tunnel builders take to prevent injury or death as they work underground?

Evaluation:
Students should be able to work cooperatively in teams; conduct thorough research on their topic; compose clear, well-written answers and questions; and play competitively but fairly with their classmates. Use the following three-point rubric to evaluate students' work during this lesson:

> Three points: Students worked effectively in their groups; researched their topic thoroughly; wrote clear, thoughtful, and interesting *Jeopardy* answers; and competed fairly with their classmates.
>
> Two points: Students worked somewhat effectively in their groups, researched their topic somewhat thoroughly, wrote some clear and interesting answers to *Jeopardy* questions, and competed somewhat fairly with their classmates.
> One point: Students had difficulty working in their groups, researched their topic but had many gaps in their knowledge, wrote a few interesting questions, and had trouble competing fairly with their classmates.

Extensions:

Subways Around the World
Most students probably aren't aware that subways are really tunnels with train tracks built in them. Have students pick one subway system to research. Examples include the system in Washington, D.C., considered one of the best in the world; the subway system in New York City; and the "Tube" in London, England. Have students research when it was built, record any new or unusual technologies or materials used in its construction, and find a map showing the system's different routes. If time permits, have students share their findings. Stimulate

discussion with questions such as the following: How is each subway alike? How is each one different? Which one do you think is the best in the world? Why?

The World's Longest Tunnels
Have student create a mural that shows scale illustrations of the world's longest tunnels. The information needed to complete the murals can be found at http://home.no.net/lotsberg/index.html.

Suggested Readings:

Structures: The Way Things Are Built
Nigel Hawkes, Collier Books, 1993.
More than fifty of the world's greatest man-made structures are discussed in this tribute to their designers and builders. Informative text, photographs, working diagrams, and cutaway drawings show how the largest, longest, highest, most massive constructions were built. It includes sections on feats of civil engineering, architectural wonders, and amazing underground construction.

Construction: Building the Impossible
Nathan Aaseng, The Oliver Press, 2000.
This book profiles eight innovative builders and their famous construction projects. Numerous illustrations, photographs and sidebars help explain the problems these early engineers were faced with an how they overcame them.

Web Links:

Tunnels: Digging In

Play Discovery Online's interactive game “How to Dig a Tunnel?” and find out how engineers bore through solid rock and scrape passages under bodies of water. Then a take a tour of the best-looking tunnels in “Explore the World's Subways.”
http://www.discovery.com/stories/technology/buildings/tunnels.html

The Chunnel (a lesson plan)
This integrated unit will illustrate the physical, economic, and cultural effects of the Chunnel on Western Europe. Each lesson (Historical Perspective, Channel Geography, 200-Year-Old Dream, Chunnel Construction, and Chunnel Economics) is guided by downloadable worksheets, newspaper articles, and many diagrams.
http://getp.freac.fsu.edu/fga/academy/eurchun.htm#activity5

Great Engineering Successes: The Channel Tunnel
The Chunnel is considered to be among the top ten engineering accomplishments of the 20th Century. It is described at this web site with easy text and animated diagrams.
http://www.brad.ac.uk/acad/civeng/marketing/civeng/succcha1.htm

World's Longest Tunnel Page
The best reference list on the web providing historical information on every kind of tunnel that has ever been created under the surface of the earth since antiquity.
http://home.no.net/lotsberg/

Holland Tunnel Story
A history of the first tunnel that connected Manhattan Island (New York City) with the rest of New York.
http://www.panynj.gov/tbt/hthist.HTM

Vocabulary:

compressed air drill
Definition: A drill that uses pressurized air to cut through rock
Context: The compressed air drill is three times more effective than gunpowder for making tunnels.

cut-and-cover technique
Definition: An open trench cut in the earth into which a premade tunnel is dropped; once the tunnel is in place, the workers cover it with soil.
Context: Because engineers aren’t able to move buildings and roads out of the way very easily, the cut-and-cover technique isn’t always the best solution for digging under cities.

excavate
Definition: Dig up or remove from the ground.

Context: In 1867, dynamite was used to excavate the Hoosac Tunnel in Massachusetts.

nitroglycerin
Definition: An explosive compound made from a mixture of glycerol and concentrated nitric and sulfuric acids.
Context: Nitroglycerin is an important chemical found in dynamite.

subway
Definition: An electric underground railway.
Context: In the Washington, D.C., metropolitan area, the subway system, known as the Metro, is the most efficient way to travel from the city to suburbs in Maryland and Virginia.

tunnel shield
Definition: A structure used at the head of a tunnel to prevent it from collapsing.
Context: Tunnel shields are frequently used when engineers construct subways, water supply systems, and sewers.

Tunnel Boring Machine (TBM)
Definition: An enormous rock-chewing machine that can create tunnels through the ground.
Context: As the 200-ton Tunnel Boring Machine works, its round cutter head grinds into the tunnel face and splits large chunks of rock.

Academic standards:

Grade level:
6-8
Subject area:
Technology
Standard: Understands the nature and uses of different forms of technology.
Benchmark: Knows that construction design is influenced by factors such as building laws and codes, style, convenience, cost, climate, and function.

Grade level:
6-8
Subject area:
Technology
Standard: Understands the nature and uses of different forms of technology.
Benchmark: Knows that manufacturing processes use hand tools, human-operated machines, and automated machines to separate, form, combine, and condition natural and synthetic materials; these changes may either be physical or chemical.

Grade level:

6-8
Subject area:
Technology
Standard: Understands the nature of technological design.
Benchmark: Knows that the design process relies on different strategies: creative brainstorming to establish many design solutions, evaluating the feasibility of various solutions to choose a design, and troubleshooting the selected design.

Credit:
Jordan D. Brown, a freelance author in New York City, enjoys writing books, magazines, and Web sites for kids and teachers.

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Name: ______________________

Design a Tunnel of the Future

Imagine that it is 2080. You and a team of engineers have been asked to build a tunnel under the Bering Strait to link Alaska and Russia. Use what you have learned about tunnels to develop a work plan for the project. Write a paragraph describing your plan and then make a sketch of your ideas. The questions below will help you get started. Imagine what new technologies may be available in the future. Let your imagination go and design a dream tunnel constructed with state-of-the art equipment. Remember, just about anything is possible!

1. How would engineers construct the underwater portion of the tunnel?

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2. What obstacles would engineers most likely face?

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3. What current technologies would you use?

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4. Now let your imagination go! Invent some new technologies that you could use to complete this project.

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Design Your Bridge!

On the back, write a summary and draw a sketch of your work plan.

Name: ______________________

Tunnels Fact Sheet

Here is some information in each of the categories the students are researching for the *Jeopardy* game.

1. History of tunnels. Roman engineers built the most extensive and complex network of tunnels in the ancient world. They built aqueducts, sloping structures used to carry water from mountain springs to cities and villages. The structures were used to carry fresh water in and wastewater out. Tunnels continued to be used throughout time, and by the 17th century, tunnels were being constructed for canals as a way to haul freight over long distances. With the invention of trains in the 19th century and cars in the early 20th century, tunnels provided additional space underground on which these vehicles could travel.

2. Tools and techniques used to build tunnels. The four main types of tools and techniques used are drilling and blasting, tunnel boring machines (TBMs), the cut-and-cover technique, and a tunnel shield. In the late 19th century and early 20th century, blasting with dynamite and then using drills was the way that engineers dug through mountains; today, they use TBMs, enormous machines with sharp teeth, for cutting through mountains. For digging underwater, engineers use the cut-and-cover technique, which allows them to float a premade tunnel into position, sink it into place, and then attach it to other sections. Finally, shield tunneling is used when digging shallow tunnels, such as subways, water supply systems, and sewers that usually are constructed on soft earth. A structure called a tunnel shield is used at the front of the tunnel to prevent it from collapsing.

3. Notable tunnels. The following are some examples of notable tunnels.

• *Holland Tunnel.* Built in New York and New Jersey in the 1920s, the Holland Tunnel cost $48 million to build and is more than 8,000 feet long. It is built underwater, and the tunnel was designed so that more cars could cross the Hudson River each day. Ventilation was the biggest challenge in constructing the tunnel, but engineer Clifford Holland solved that problem by constructing 84 powerful electric fans that draw fresh air into the tunnel and blow dirty air out. Unfortunately, fans can be dangerous; in 1949, a truck carrying chemicals exploded the tunnel, injuring 69 people and causing extensive damage to the structure. As a result, strict standards for transporting chemicals and explosives in tunnels were established.

• *Chesapeake Bay Bridge-Tunnel.* Completed in 1964, the tunnel is located in Cape Charles and Virginia Beach in Virginia. Its total length is 89,760 feet, and it cost $200 million to construct. The majority of the bridge-tunnel is above water, but it dips over and under open waters with a complex web of artificial islands, tunnels, and bridges. More than 5,000 piers support the structure. Shortly after it opened, it was selected as one of the seven engineering wonders of the modern world in a worldwide competition that included more than 100 major projects.

• *Japan's Seikan Tunnel.* After 10 years of construction, the Seikan tunnel opened in 1974. The railroad tunnel links the main Japanese island of Honshu with the northern island of Hokkaido, and it cost $7 billion to construct. The tunnel is 33 miles long, the longest railroad tunnel in the world. The underwater portion is 14.5 miles, and it is said to have been the hardest underwater dig ever attempted. Engineers used drilling and blasting to construct it; because the ground was so earthquake scarred, TBMs could not be used.

4. New tunnel technology. Engineers now have access to imaging technology that allows them to make a scan of the inside of the earth. The scan works by computing how sound waves travel through the ground. The technology enables engineers to know the obstacles they may face before they begin digging and drilling. Another advance in tunnel technology is taking place in Switzerland. Engineers are working on tunnels that cut through the base of the Swiss Alps. To work on this project, engineers have designed special TBMs that can cut through the hard, shifting rock found in these mountains. Finally, to give structural engineers the time they need to build a tunnel properly, chemical engineers are working on new ways to mix concrete so that it hardens at different rates instead of the standard time of 90 minutes to 3 hours. The new concrete ideally could be brought to the site at the time of construction and be mixed at the convenience of the work crew. Because of this new property, the concrete will stay moist until the engineers are ready to use it. This technique is currently in the experimental phase.