Design a Dome

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Lesson Focus

Lesson focuses on the engineering behind building framing for structures, and explores examples of geodesic domes and other buildings. Students work in teams to design and build a small dome frame out of everyday items that can hold a weight on top without collapsing.

Lesson Synopsis

The "Design a Dome" activity explores construction and engineering design. Students work in teams to design a domed structure out of everyday materials that is strong enough to support 120 grams of coins or candy on top. They will design the frame for their dome on paper, select and gather materials, construct their dome, and test it. They present their domes to the class and complete reflections on the lessons learned.

Age Levels

8-18.

Objectives

- Learn about engineering design and redesign.
- Learn about construction techniques
- Learn about teamwork and problem solving.

Anticipated Learner Outcomes

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

- construction
- engineering design
- teamwork

Lesson Activities

Students learn about domes and work in teams to construct their own using everyday materials. They will design the frame for their dome on paper, gather materials, construct their dome, test it, and present their work to the class. They also complete a reflection sheet on the activity.

Resources/Materials

- Teacher Resource Documents (attached)
- Student Resource Sheet (attached)
- Student Worksheet (attached)

Alignment to Curriculum Frameworks

See curriculum alignment sheet at end of lesson.

Internet Connections

- TryEngineering (www.tryengineering.org)
- Buckminster Fuller (www.pbs.org/wnet/americanmasters/r-buckminster-fuller-about-r-buckminster-fuller/599/)
- Buckminster Fuller Archive at Stamford University (http://library.stanford.edu/collections/r-buckminster-fuller-collection)

Recommended Reading

- Fuller Houses: R. Buckminster Fuller's Dymaxion Dwellings and Other Domestic Adventures (ISBN: 978-3037781418)
- Ultimate Guide to House Framing (ISBN: 978-1580114431)

Optional Writing Activity

- Write an essay or a paragraph about why sturdy framing is so important to construction. How have the materials used for building framing changed as buildings have become taller and taller?

For Teachers:
Teacher Resource

◆ Lesson Goal
The "Design a Dome" activity explores construction and engineering design. Students work in teams to design a structure with an internal frame and optional exterior decorations that is strong enough to support 120 grams of coins or candy on top. They will design the frame for their dome on paper, select and gather materials, construct their dome, and test it. They present their domes to the class and complete reflections on the lessons learned.

Lesson Objectives
- Learn about engineering design and redesign.
- Learn about construction techniques
- Learn about teamwork and problem solving.

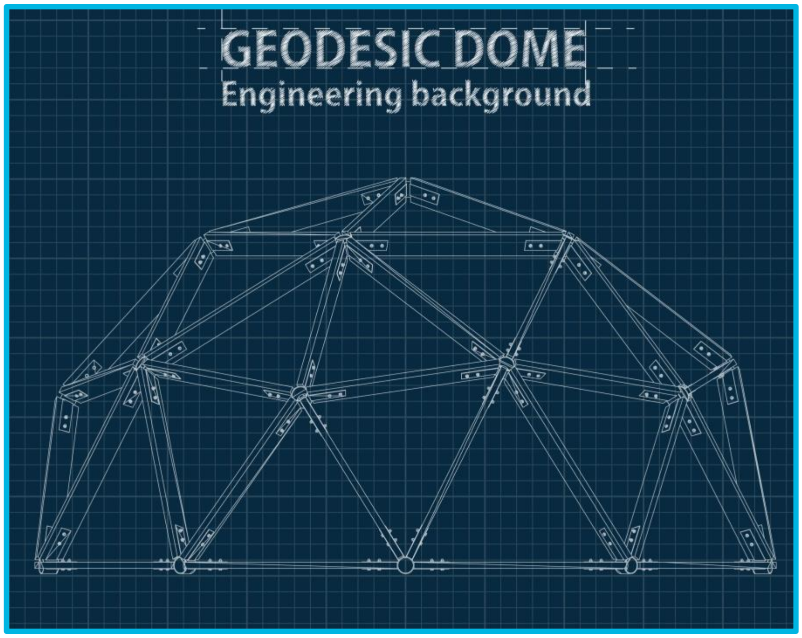
Materials
- Student Resource Sheets
- Student Worksheets
- Student Team Materials: range of materials including but not limited to cardboard, wooden dowels, tape, foil, construction paper, tissue paper, glue, string, rubber bands, wire, popsicle sticks, paper cups, straws, pipe cleaners, paper clips, screen, fabric.

Procedure
1. Show students the student reference sheets. These may be read in class or provided as reading material for the prior night's homework.
2. To introduce the lesson, discuss the wide range of shapes and sizes of buildings and have the class consider the advantages or disadvantages of different shapes. Discuss the geodesic dome and have the group consider why domes can be a good shape choice for some projects and environments, examples are the South Pole dome and dome design camping tents.
3. If possible, have students consider the structure of a geodesic dome. The resources at www.bfi.org will give some insights into geodesic dome use and history.
4. Teams will consider their challenge and draw a diagram of their planned dome on paper and make a list of the materials they think they will require.
5. Teams next construct their domes with the requested materials list. Teams may request additional materials during the construction process or may trade materials with other student teams.
6. Teams then suspend their dome on the strings provided by the teacher, observe other dome designs, and score their own work.
7. Student teams complete a reflection sheet and share their experiences with the class.

Time Needed
One to two 45 minute sessions.

Student Resource: Domes and Construction

◈ The Geodesic Dome



Many structures require framing to provide shape and strength before an outer shell is created. A good example is the geodesic dome. A geodesic dome is a spherical or partial-spherical shell structure or lattice shell based on a network of great circles (geodesics) lying on the surface of a sphere. The geodesics intersect to form triangular elements that have local triangular rigidity and also distribute the stress across the entire structure. Walther Bauersfeld was a German engineer, employed by the Zeiss Corporation, who, on a suggestion by the German astronomer Max Wolf, started work on the first projection planetarium during 1912. Bauersfeld completed the first planetarium, known as the Zeiss I model during 1923, which is considered the first geodesic dome derived from the icosahedron, more than 20 years before Buckminster Fuller reinvented and popularized this design. Although Fuller was not the original inventor, he developed the intrinsic mathematics of the dome, thereby allowing popularization of the idea -- for which he received a U.S. patent in 1954. Spaceship Earth at Epcot, Walt Disney World, in Florida, USA is a geodesic sphere.

◈ Uses of Domes

Geodesic domes have been used as the basis of many buildings and structures including collapsible camping tents. The National Science Foundation image to the right shows the deconstruction of a geodesic dome which for about three decades sheltered polar researchers and support crews who lived at the bottom of the world. The dome, spanning 164 feet and topping out at about 52 feet high, was dedicated in January 1975. It shielded a collection of buildings that housed scientists and support personnel year-round from wind and snow. The structure far outlived its projected expiration date.

Student Worksheet:

Engineering Teamwork and Planning

You are part of a team of engineers given the challenge of building a dome to hold 120 grams of coins, candy, or other materials selected by your teacher. You'll have lots of materials to use such as cardboard, wooden dowels, tape, foil, construction paper, tissue paper, glue, string, rubber bands, wire, popsicle sticks, paper cups, straws, pipe cleaners, paper clips, screen, and other readily available materials. Your structure must be at least 14 cm tall measured from the top of the dome to the bottom.

Planning and Design Phase

Think about the different ways you can use the materials provided to construct a dome structure. You may add a skin or shell out of different materials, or have the frame be the full product. On a separate piece of paper, draw a diagram of your planned dome, and in the box below, make a list of the parts you think you might need. You can adjust this later and also add more materials during construction.

Materials Needed:

Construction Phase

Build your dome and make any adjustments during construction that you like, including asking for additional materials. You can also trade materials with other student teams if they have extra items you would like to incorporate.

Classroom Testing

Your teacher will suspend your dome as well as those made by other teams. You'll receive points based on the following variables.

Student Worksheet (continued):

Evaluation

Complete the evaluation questions below:

1. How similar was your original design to the actual dome you built?

2. If you found you needed to make changes during the construction phase, describe why your team decided to make revisions.

3. Which dome that another team made was the most interesting to you? Why?

4. Do you think that this activity was more rewarding to do as a team, or would you have preferred to work alone on it? Why?

5. If you could have used one additional material (tape, glue, wood sticks, foil -- as examples) which would you choose and why?

6. Do you think your dome would have been able to hold 600 grams of weight? Why or why not?

For Teachers:
Alignment to Curriculum Frameworks

Note: Lesson plans in this series are aligned to one or more of the following sets of standards:

- U.S. Science Education Standards (http://www.nap.edu/catalog.php?record_id=4962)
- U.S. Next Generation Science Standards (http://www.nextgenscience.org/)
- International Technology Education Association's Standards for Technological Literacy (http://www.iteea.org/TAA/PDFs/xstnd.pdf)
- U.S. National Council of Teachers of Mathematics' Principles and Standards for School Mathematics (http://www.nctm.org/standards/content.aspx?id=16909)
- U.S. Common Core State Standards for Mathematics (http://www.corestandards.org/Math)
- Computer Science Teachers Association K-12 Computer Science Standards (http://csta.acm.org/Curriculum/sub/K12Standards.html)

◆National Science Education Standards Grades K-4 (ages 4-9)

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of the activities, all students should develop an understanding of

- Properties of objects and materials

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- Abilities of technological design
- Abilities to distinguish between natural objects and objects made by humans

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- Changes in environments
- Science and technology in local challenges

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- Science as a human endeavor

◆National Science Education Standards Grades 5-8 (ages 10-14)

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- Abilities necessary to do scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop an understanding of

- Motions and forces

CONTENT STANDARD E: Science and Technology

As a result of activities in grades 5-8, all students should develop

- Abilities of technological design
- Understandings about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- Science and technology in society

For Teachers:
Alignment to Curriculum Frameworks

◆National Science Education Standards Grades 9-12 (ages 14-18)

CONTENT STANDARD A: Science as Inquiry
As a result of activities, all students should develop
- Understandings about scientific inquiry

CONTENT STANDARD B: Physical Science
As a result of their activities, all students should develop understanding of
- Motions and forces

CONTENT STANDARD E: Science and Technology
As a result of activities, all students should develop
- Abilities of technological design
- Understandings about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives
As a result of activities, all students should develop understanding of
- Science and technology in local, national, and global challenges

CONTENT STANDARD G: History and Nature of Science
As a result of activities, all students should develop understanding of
- Science as a human endeavor
- Historical perspectives

◆Standards for Technological Literacy - All Ages

Technology and Society
- Standard 6: Students will develop an understanding of the role of society in the development and use of technology.

Design
- Standard 8: Students will develop an understanding of the attributes of design.
- Standard 9: Students will develop an understanding of engineering design.
- Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Abilities for a Technological World
- Standard 11: Students will develop abilities to apply the design process.

The Designed World
- Standard 20: Students will develop an understanding of and be able to select and use construction technologies.