CHALLENGER CENTER'S JOURNEY through the UNIVERSE

Earth Systems Science

This lesson is taken from an education module developed for Challenger Center's *Journey through the Universe* program. *Journey through the Universe* takes entire communities to the space frontier.

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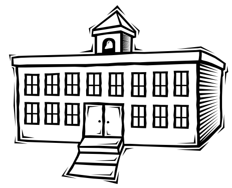
January 2002

Grade Level
K-4



Lesson 2: Good Old Earth Materials

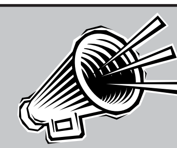
ESSENTIAL QUESTION
What Earth materials and construction styles are best at withstanding earthquakes?

Lesson Summary

This lesson allows students to investigate different types of building structures and how they stand up to earthquakes. The students will discuss why different types of buildings are better equipped to handle earthquakes than others. Parameters include shape, construction material, and height of the building. As well as the magnitude, duration, and direction of shaking.

Lesson Duration

Two 45-minute class periods



OBJECTIVES
Students will be able to:

- Build structures using three different types of materials.
- Test the strength of construction methods and materials during a simulated earthquake.

CORE K-4 STANDARDS

NRC Standards

- STANDARD D3: The surface of the earth changes. Some changes are due to slow processes, such as erosion and weathering, and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes.
- STANDARD F3: Some resources are basic materials, such as air, water, and soil; some are produced from basic resources, such as food, fuel, and building materials; and some resources are nonmaterial, such as quiet places, beauty, security, and safety.
- STANDARD F4: Some environmental changes occur slowly, and others occur rapidly. Students should understand the different consequences of changing environments in small increments over long periods as compared with changing environments in large increments over short periods.

Science Overview

Building Construction

Since the beginning of mankind, humans have turned to Earth materials for shelter from the harsh environment. We have constructed housing from the resources made available to us by the natural world; we have built igloos in Alaska and grass huts in Africa to protect ourselves. Sometimes we have been successful in sheltering ourselves from severe conditions, but sometimes we have failed. Most importantly, we have learned from our successes and failures, and are constantly discovering ways in which we can improve building construction.

Some buildings have withstood the test of time. The Ancient Egyptians built solid structures that have lasted until today. Five thousand years ago, the Great Pyramid of Khufu was constructed from over two million stone blocks weighing an average of 2.5 tons each. The Incan and Mayan civilizations also built beautiful solid structures, many of which are still standing. Most of these ancient buildings were constructed for religious purposes, as tombs and places of worship. They were carefully designed to last, and have thus far been successful.

Building Materials

Certain materials may be used in building construction for a specific purpose, or they could be chosen based on availability, expense, insulation, and a number of other reasons. There are, of course, advantages and disadvantages to each kind of building material.

Stone is the material of the oldest structures still standing. It resists fire, water, and insects. The natural flexibility of the joints between stones helps to resist damage from earthquakes and other natural disasters. Stone has been used to build houses, dams, bridges, and roadways. Walls that do not use mortar (such as stone) have a better chance of withstanding rain and snow, which can get trapped in seams and cause them to break apart during the freeze-thaw cycle. Brick, which can be a less expensive alternative to stone in many parts of the world, needs mortar to be effective. Like stone, brick will not burn or melt in most cases, but it may be less resistant to damage caused by earthquakes, for example.

The most widely available and inexpensive building material is wood. If constructed properly, wood structures (such as log cabins) can withstand earthquakes and most weather. It will be damaged from too much water, and waterproofing a wooden building can be expensive. It is not fire resistant, but is strong if it is kept dry and has a solid foundation.

Concrete is a combination of crushed stone, sand, cement, and water, and was invented by Joseph Monier in 1867. Like stone, it has great strength under compressive forces (and does not require mortar). Sometimes concrete is reinforced with steel rods, increasing its strength. Concrete structures tend to have great longevity and ease of construction. Concrete is also fairly inexpensive and fire-resistant.

Steel framing can be an alternative to wood; it can be lighter than other framing materials, and it has the highest strength-to-weight ratio of any building material. It is fire-resistant, and, like wood, can withstand earthquakes and weathering if assembled properly. Most buildings in cities today are built with steel frames, and an increasing number of houses rely on steel as well.

All of these building materials have to serve their purpose, and what that purpose is depends primarily on location. Some areas are concerned with fires, some with tornadoes; and everyone is concerned with cost. No matter what the regional concerns are, buildings must be constructed to withstand a number of hazardous events.

System Interactions

Human development has, over time, been put to the ultimate test: Mother Nature. The Earth itself hurls obstacles in the way of human survival every day, and they come from every direction and source imaginable. Earth's biosphere (all life on Earth) is greatly affected by the atmosphere, the hydrosphere, and the geosphere via natural disasters.

The atmosphere consists of all air and weather events on Earth. It is capable of producing powerful winds which have destroyed many homes and buildings in various ways. In a region of the United States referred to as "Tornado Alley," there can be as many as 100 tornadoes per year in every state within the Alley. These tornadoes can have winds from 320 to 485 kilometers per hour. Wind damage occurs in areas such as the Atlantic and Gulf Coasts.

These areas also experience occassional hurricanes which can be devastating, and can kill hundreds of people every year. Even storms that are not as massively destructive as tornadoes or hurricanes can damage or destroy buildings and homes, and do every day.

Like wind damage, water damage can range from mild to severe. The hydrosphere, Earth's water system, can be extraordinarily destructive to human developments. Floods can bury entire towns in hours, and they can harm structures and their foundations beyond repair. Buildings that are not properly constructed can leak water in the calmest rain, damaging their interior and their structure. Huge waves called tsunamis can be generated by earthquakes occurring underneath the oceans, and when they can reach shore, can be overwhelmingly destructive. Most human structures are incapable of withstanding the powerful blow of a tsunami.

The land and rock of the Earth, its geosphere, can also play a role in destroying human developments. The Earth is constantly evolving and changing, and its core is continuously cooling. The heat released in the cooling process is transferred toward the surface, and one event in which the heat from inside the Earth can be seen is a volcanic eruption, which demolishes everything in its path. As the Earth is settling, landslides may break chunks of land off of mountains and hills, causing destruction to any buildings nearby. Perhaps the most dramatic and devastating way in which the geosphere affects humans is by earthquakes.

Earthquakes

Earth's surface is composed of huge tectonic plates that are moving over geologic timescales, gradually restructuring the Earth's surface. As the plates move and slide past each other, they press upon one another, creating a huge amount of stress along the fault, the line at which the plates come together. Once so much pressure has built up that the rocks cannot stretch any more, there is a sudden release of stress, and an earthquake occurs as the rock is snapped apart. Along with the earthquake itself, tremors may be felt as foreshocks prior to the event, and aftershocks that follow. The release of pressure sends out shock waves in every direction from the focus, which is the earthquake's point of origin below the surface of the Earth. The waves die out as they spread away from the epicenter, the place on the surface directly above the focus, and so the greatest effects are felt nearby.

When an earthquake occurs, it does not just shake the ground back and forth; different types of waves shake the ground in different ways and directions. The P wave (pressure wave) squeezes and then pulls apart the ground in the same direction it is traveling, like people standing in line pushing each other back and forth. The P wave moves more quickly than the S wave, which moves up and down or back and forth, like a wave traveling through a shaking rope or flag.

Finding the location of an epicenter can be tricky. The earliest seismoscope (an instrument that indicates the occurrence of an earthquake) was invented by Chang Heng, a Chinese philosopher, in A.D. 132. When an earthquake occurred, one of eight balls would be released; which one depended on the direction to the quake. This way, Chang would know in which direction to send help, but not necessarily the earthquake's exact location. Today, scientists use instruments called seismographs to record the intensity, direction, and duration of an earthquake. Because P and S waves move at different (known) speeds, scientists studying earthquakes can record how long it takes for each kind of wave to reach a seismograph. Using the difference in time, they can calculate the distance from the seismic station to the epicenter of the earthquake. However, with only one seismic station, they cannot determine the direction of the earthquake, but can only draw a circle around the station with all possible epicenters located on that circle. The location circle of a second seismic station will intersect with the first in two places, narrowing the possible sources of the earthquake. However, with three or more stations, an exact location can be pin-pointed.

Intensity of an earthquake can be measured on a scale created by the Italian seismologist Giuseppe Mercalli. It is a measure of how much damage an earthquake causes to buildings, the effects of an earthquake on human inhabitants, etc. Although the intensity at which you experience an earthquake depends on your distance from the epicenter, its magnitude is intrinsic to the amount of energy released by the earthquake itself. Seismographs can measure intensity at various locations, and the data can be extrapolated to the location of the epicenter to find the magnitude. The measure of magnitude is a scale which was developed by the American seismologist Charles F. Richter in 1935, and is known today as the Richter scale. The Richter scale ranges from 0 to 9, although there is no real upper limit. The scale is logarithmic, which means that for every increase of one on the Richter scale, the ground shakes ten times as much.

Earthquakes occur more often than you may think. The average number of earthquakes that occur per day is called the earthquake frequency. Earthquakes that are considered moderate (5.0 to 5.9 on the Richter scale) occur twice a day somewhere in the world, and many more light tremors, that heavy sleepers may not even notice, occur daily. Although these quakes can cause damage, especially to structures not built to withstand them, it is usually the rarer, stronger earthquakes that cause devastating destruction to humans and human development.

The greatest natural disaster in recorded human history was an earthquake that occurred in China in 1556. The Shensi Province earthquake was felt in over half of China. An estimated 830,000 people died, some from subsequent fires, landslides, and floods. On Good Friday in 1964, an earthquake measuring 8.4 to 8.6 on the Richter scale struck Alaska, one of the most severe North American earthquakes ever recorded. It elevated approximately 181,000 square kilometers of land and produced destructive tsunamis as far south as California. North America's biggest earthquake took place in New Madrid, Missouri in 1811, and was so strong that it rang church bells in Washington, D.C., more than 1,000 kilometers away. The famous San Francisco earthquake in 1906, with a magnitude of 8.3, wiped out gas and electricity to the whole city and created a fire which killed 700 people.

Withstanding Damage from Earthquakes

In cases of such extreme demolition and devastation, it is difficult to imagine anything capable of weathering the destruction. However, it is possible to "earthquake-proof" a building by paying attention to certain factors, such as the building materials, the design of the structure, and the material upon which the structure rests.

Building damage occurs because of both the intensity and the duration of vibration. Certain materials are able to hold up against both of these factors more effectively than others. For example, mortar in brick and masonry crumbles under even moderate trembling. Damaged concrete and rotten wood will not survive a modest earthquake, but concrete reinforced with metal or fiberglass will stand up to the toughest beating.

Damage depends not only on what kinds of materials buildings are made of, but the manner in which they are constructed. Small buildings such as houses react more to higher frequencies, but large buildings such as skyscrapers react more to lower frequencies. Since the wave frequency lowers as it travels, houses may receive more damage toward the epicenter than larger buildings, but larger buildings will receive more damage than houses as the distance to the epicenter increases, balanced against the weakening of the shock wave as it travels. In general, buildings that are built with some flexibility rather than rigidity stand up better in an earthquake. Rigid buildings crack more easily, whereas if there is some give to the structure (or material), it can flow and bend with the waves, rather than resist them.

A firm foundation is crucial to maintaining structure in an earthquake. Buildings which have solid foundations with a continuous perimeter, and that are fastened securely to their foundations, have a much better chance of withstanding an earthquake than buildings with shaky or depleting foundations. The soil on top of which the building sits is important in establishing foundation, as well; a soft, loose soil shakes much more severely than hard rock. This is partly because when earthquake waves pass from rock to soil, they slow down, but increase the amplitude of the shaking.

TEACHER MATERIALS

Activity 2
(for Shake Table Model)

- Cardboard Soda tray
- Shoe box lid
- Rubber bands
- Binder clips
- Kite string
- Paper clips

STUDENT MATERIALS

Activity 1: (per class)

- Student Worksheet 1
- Building Construction Task Cards
- About 50 Popsicle sticks
- Block of clay
- 6 Styrofoam® pieces (about 1′ x 1′)
- Sugar cubes (1 box per structure)
- Peanut butter or frosting
- An assortment of cardboard pieces
- Aluminum window screen scraps
- One box of pipe cleaners
- One box of T-pins
- Straws
- Two-sided tape
- Glue

Activity 2: (per group of three)

- Student Worksheet 2
- Cardboard Soda tray
- Shoe box lid
- Rubber bands
- Binder clips
- Kite string
- Two-sided tape

Lesson Plan

Warm-Up

Have students brainstorm different materials that are used to make buildings, write their ideas on the board. *(Answer: Various materials are used to construct buildings, alone or in combination, such as steel, concrete, stone, wood, and brick. Concrete is the most widely used construction material in the world. It is comprised of sand, gravel, and crushed stone, held together with cement.)* Tell studetns these are called Earth materials. Ask students why they think they were given this name. *(Answer: they come from the Earth)* How do we get each of these materials from the Earth? *(Answer: see Science Overview).*

Pre-assessment

Based on the class' brainstorm list, ask students what materials they think are the strongest. *(Answer: see Science Overview for strengths and weaknesses of each material)* Ask students what materials their homes or apartment buildings are make of. Ask students if strength is the only factor that affects a buildings ability to withstand an earthquake. *(Answer: Most students will say that the stronger the building material, the more resilient the building. However, building construction also plays a role.)*

ACTIVITY 1: Building Construction

ACTIVITY 1: Building Construction

Preparation & Management

- Divide students into three different groups "Wood," "Masonry," and "Steel."
- Place all of the materials in a central location in the classroom.

Teaching Tip

Depending on classroom size, you may have two or three groups for each building material.

Procedures

1. As a class discuss the following: When you design buildings, there are a number of variables you need to consider:
   - Height of the building.
   - Soil beneath the building.
   - Regional topography.
   - Intended function of the building (e.g. hospital, fire station, office building).
   - Proximity to other buildings.
   - Shape of the building. Geometric shapes such as a square or rectangle or buildings in the shape of an L, T, U, H, +, O, or a combination of these.

2. Have students go to their workstations and read the Task Card directions. These directions will set parameters for the building the students will create.

3. Have students create a profile of their building on Student Worksheet 1. This should include:
   - Size
   - Number of stories
   - Location
   - Style and shape
   - Building use

ACTIVITY 1: Building Construction

4. Have students draw a diagram of the building they are going to build on Student Worksheet 1.

5. Students should then construct their building.

Reflection & Discussion

When students have completed their construction, discuss the following questions as a class.

- Which type of construction do you think is the strongest? Why?
- Which are more stable, one or two story structures? Why?
- Do you think the shape of a building makes it stronger?
- What would you change to make your building stronger?

Transfer of Knowledge

Discuss with students how different changes on the Earth can be dangerous to buildings. Have them answer the following questions on Student Worksheet 1:

- How do you think your building would withstand changes to the environment, such as floods, hurricanes, or earthquakes?
- What modifications would you make if your building was on the beach?
- How would you test your building to see if it could withstand a hurricane or an earthquake?

Answers will vary.

ACTIVITY 1: Building Construction

ASSESSMENT

4 Points
- Profile, diagram, and model are complete.
- Model accurately follows both the profile and the diagram.
- Answers to questions on Student Worksheet 1 are complete and accurate.

3 Points
- Profile, diagram, and model are complete.
- Model somewhat follows both the profile and the diagram.
- Answers questions on Student Worksheet 1 are complete and mostly accurate.

2 Points
- Profile, diagram, and model are incomplete.
- Model somewhat follows the profile or the diagram.
- Answers to questions on Student Worksheet 1 are complete.

1 Point
- Profile, diagram, and model are incomplete.
- Model does not follow the profile or the diagram.
- Answers to questions on Student Worksheet 1 are incomplete.

0 Points
- No work turned in.

Placing the Activity Within the Lesson

In Activity 1, students explored various building materials and designs. Students will test how well their structures will resist damage from earthquakes in Activity 2.

ACTIVITY 2: Earthquake Test

Preparation & Management

- Students should work in the same groups as they did in the first activity to test their buildings.

- Construct a shake table prior to the students to serve as a model, and so you can assist students with any problems they may have. See Student Worksheet 2 for directions. The movement of the shake table is done by pulling on the kite string from each end and underneath the box. The rubber bands simulate movement and shaking.

Procedures

1. Ask students how they think their buildings will stand up during an earthquake. Ask students how they could test their buildings. *(Answer: shake it to simulate an earthquake)*

2. Explain to students that they are going to build a shake table to simulate an earthquake. Show students the model you created earlier. Demonstrate how the back-and-forth motion of the shake table simulates primary waves (P Waves), and vertical or side to side motions simulate secondary waves (S Waves).

3. In their groups, students should assemble the shake table according to the instructions in Student Worksheet 2.

4. Once students have completed their shake table explain to them that they can simulate the earthquake waves by pulling on each of the strings.

5. Have students attach their buildings to the shake table using two sided tape. Have them test how well their building holds up to the stress of an earthquake by pulling 4-5 times on each string.

6. Have students observe the motions of their structures as the shake table moves.

7. Students should record their observations after each shake and then complete the questions on Student Worksheet 2.

Reflection and Discussion

Have each group report to the class the results of their shake test. Which parts of their building were resilient? Which parts were weak? Did anything surprise them about the way their building reacted to the simulated quake? Students should use the insights from each group to recommend improvements to their own building. Ask students if the strongest materials were the most resilent to the shakes. *(Answer: not always, building that can sway with the shakes are usually the most resilent.)*

Transfer of Knowledge

Have students complete the following questions on Student Worksheet 2 after they test their building.

- Which part of your building moved the most? The least?
- How could you improve your structure?
- What other building materials might you use?

Answers will vary.

ACTIVITY 2: Earthquake Test

ASSESSMENT

4 Points
- The Shake Table was constructed correctly.
- Student accurately and thoroughly described how their building reacted to each shake.
- Student answered all questions on Student Worksheet 2.
- Answers used creative and reasonable ways to improve their building and shows a deep understanding of the problem and solution.

3 Points
- Students met 3 of the 4 above criteria.

2 Points
- Students met 2 of the 4 above criteria.

1 Point
- Students met 1 of the 4 above criteria.

0 Points
- No work completed.

Placing the Activity Within the Lesson

After building various structures and subjecting them to shake-tests, students should realize that different materials and different designs affect a structures stability. Students should also realize that the most rigids structures and the strongest materials may not survive earthquakes as well as structures that are able to sway or flow with the quake.

Lesson Closure

As a class, create a pros and cons list for using different Earth materials for constructing buildings. Discuss what might be some unusual building materials. Could you construct a building out of water? How about mud? How would these hold up to different environmental conditions?

Supplemental Resources

Earthquakes
http://pubs.usgs.gov/gip/earthq1

Earthquakes for Kids
http://earthquake.usgs.gov/4kids/

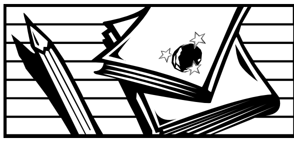
Making a Shake Table
http://mceer.buffalo.edu/education/exercises/shtable.asp

Plate Tectonics - the Cause of Earthquakes
http://www.seismo.unr.edu/ftp/pub/louie/class/100/plate-tectonics.html

Understanding Earthquakes
http://www.crustal.ucsb.edu/ics/understanding

Acknowledgments

This lesson was adapted from a USGS activity.



STUDENT WORKSHEET 1 - BUILDING CONSTRUCTION

Name ____ **Date** _______

Building Profile

Size -

Number of Stories -

Location -

Style and Shape -

Building Use -

Diagram

Questions

1. How do you think you building would withstand changes to the environment, such as floods, hurricanes, or earthquakes?

   ____

2. What modifications would you make if your building was on the beach?

   ____

3. How would you test your building to see if it could withstand a hurricane or an earthquake?

   ____

STUDENT WORKSHEET 2 - EARTHQUAKE TEST

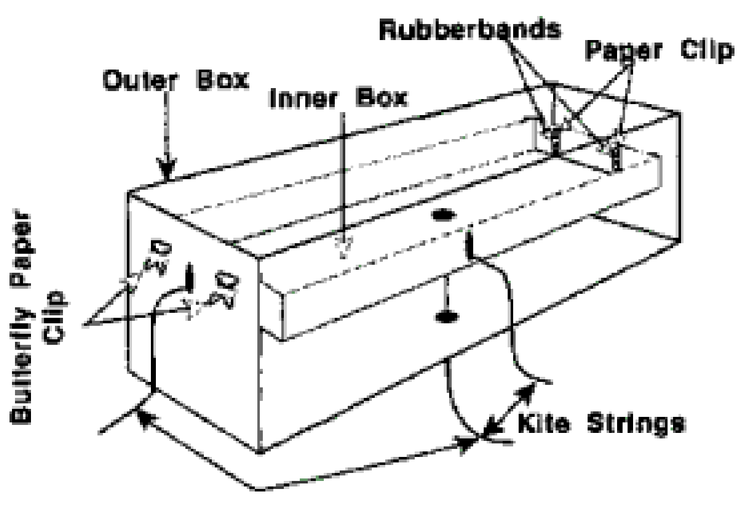
Name ____ **Date** _______

1. Build a shake table by following the directions below.
   - Place two holes in both short ends of the soda tray near the center and about 10 cm apart.
   - Place two holes in both short ends of the shoebox lid near the center and about 6 cm apart.
   - Place a third hole in between the first two holes in one of the short ends of both the shoebox lid and the soda tray. Attach a string through the hole in the shoebox lid.
   - Place a hole in the center of the top of the shoebox lid and in the center of the bottom of the soda tray. Attach a string through the hole in the shoebox lid.
   - On one of the long sides of the shoebox lid and the soda tray put a hole in the center of the side. Attach a string through the hole in the shoebox lid.
   - Push a rubber band through each hole in the shoebox lid and secure using a paper clip.
   - Pull each rubber band through the hole in the soda tray and secure using the binder clip.
   - Open the binder clip and pull each rubber band until there is enough tension to suspend the shoe box lid.
   - Thread the string through the holes in the bottom and both sides of the soda tray.

2. You can simulate earthquake waves by pulling on each of the strings.

3. Attach your building to the shake table using two sided tape.
   Test how well your building will hold up to the stress of an earthquake. Simulate earthquake waves by pulling 4-5 times on each string.

4. Observe the motions of your building as the shake table moves. Record your observations after each shake on Student Worksheet 2 and then complete the questions.



STUDENT WORKSHEET 2 - EARTHQUAKE TEST

Observations

Trial	*Observation of Building*
Shake 1	
Shake 2	
Shake 3	
Shake 4	
Shake 5	

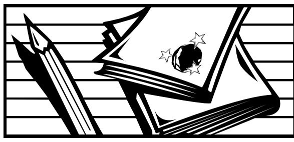
Questions

1. Which part of your building moved the most? The least?

2. How could you improve your structure?

3. What other building materials might you use?

4. How could you change the design of building to make it stronger?



BUILDING CONSTRUCTION TASK CARDS

Making Wood Frame Structures

Procedure:
Construct a one- or two-story frame building using Popsicle sticks with clay for jointing. Let the building sit until the clay is stiff. Use a piece of Styrofoam to make a foundation for the building. Cut the Styrofoam the same size as the external perimeter of the house with a cutout for a basement. Try setting the building on the Styrofoam or fastening the building to the Styrofoam with clips, tacks, or an adhesive.

Strengthening Your Building:
Try cross or diagonal bracing to further stabilize your building. Cross-bracing means you put in vertical "X" shaped braces between the popsicle stick walls. Try different materials for your crossbraces and see which works best: popsicle sticks, kite string, or straws.

Making Masonry (Brick, Stone or Adobe) Structures

Procedure:
Construct a one- or two-story rectangle or L-shaped buildings on a Styrofoam base, using sugar cubes for bricks, cardboard for the floor and roof; and peanut butter, frosting, or double-sided tape for mortar. Try setting the building on the Styrofoam or somehow connecting it to the Styrofoam with clips, tacks, or an adhesive.

Strengthening Your Building:
Carefully cut pieces of screen smaller than the size of each of the walls. Spread a very thin layer of peanut butter or frosting on each screen and carefully attach the screen to each of the inside walls of the first story. Reinforce the corners with extra peanut butter from inside. This is a model of a reinforced masonry structure.

BUILDING CONSTRUCTION TASK CARDS

Making Steel Frame Structures

Procedure:

Construct a model of a modern steel framed high-rise using pipe cleaners. Bend the end of one pipe cleaner around the end of the other. Do not twist the ends together. Attach each model to a Styrofoam base with T-pins. A steel frame structure looks sort of like a jungle gym. However, the finished building has walls and windows.

Adding the Walls:

Make cardboard or paper walls and add them to your structure. Try other materials for the walls and cross-bracing to strengthen the structure. Cross-bracing means you put in vertical “X" shaped braces between the popsicle stick walls. Try different materials for your crossbraces and see which works best: popsicle sticks, kite string, straws.

Challenger Center Programs

The internationally acclaimed **Challenger Learning Center** Network currently consists of state-of-the-art, innovative educational simulators located at 49 sites across 29 states, Canada, and the United Kingdom. Staffed by master teachers, the core of each Center is a two-room simulator consisting of a space station, complete with communications, medical, life, and computer science equipment, and a mission control room patterned after NASA's Johnson Space Center. See *www.challenger.org* for information.

A joint initiative of Challenger Center for Space Science Education, the Smithsonian Institution, and NASA, ***Voyage — A Journey through our Solar System*** is a space science exhibition project that includes permanent placement of a scale model solar system on the National Mall in Washington, DC, and at locations all over the world. See *www.voyageonline.org* for information.

Space Day℠ launches new *Design Challenges* created by Challenger Center each school year. The inquiry-based challenges are designed to inspire students in grades 4-8 to create innovative solutions that could aid future exploration of our solar system. See *www.spaceday.org* for information.

Challenger Center's ***Journey through the Universe*** program provides under-served communities with diverse national resources, including K-12 curriculum materials, teacher workshops, classroom visits by scientists from all over the country, and Family Science Nights. See *www.challenger.org/journey* for information.

The **MESSENGER** spacecraft (MErcury Surface, Space ENvironment, GEochemistry and Ranging) is to be launched in 2004 and go into Mercurian orbit in 2009. Challenger Center is one of the partner organizations charged with MESSENGER education and public outreach activities. See *www.messenger.jhuapl.edu* for information.

Through the Challenger Center **Speakers Bureau, Voyages Across the Universe**, staff members speak to student audiences of 30-1,000, conduct workshops for 100-300 educators, give keynote and featured presentations at conferences, as well as conduct Family Science Nights at the National Air and Space Museum, and other facilities across the nation, for audiences of 300-1,000 parents, students, and teachers. See *www.challenger.org/speakers* for information.