Cubes - II

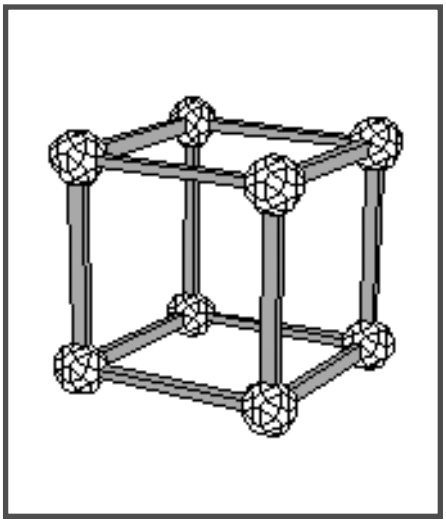
Mathematics
Basic Concept

Lesson Objective:
Students will learn about the numbers 2, 3, and 5 in relation to the cube by using shadows.

Prerequisite skills:
Ability to recognize various polygons and connect then to numbers and symmetries in 2 and 3 dimensions ("Shape and Number," "What is Reflection Symmetry?" "2-D and 3-D Shapes," "3-D Triangles," and "Speed Lines!). Ability to build and describe the properties of the cube ("Cubes - I").

Time Needed:
One class period of 45-60 minutes.

Materials Needed:
- Two Zome System Creator Kits for class of 25-30 students
- Overhead projector or sunlight
- Shadow casting surface (screen for overhead projector; white cardboard for sunlight)

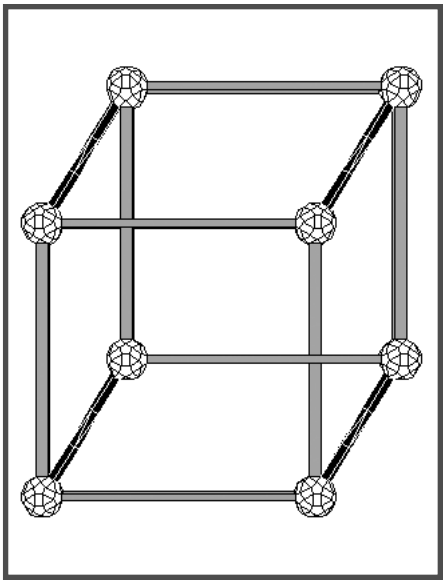


Procedure:
Regroup the class into the teams from the "Cubes - I" exploration. Each team member should have a cube model (one small, one medium, and one large cube per team) built during that lesson.

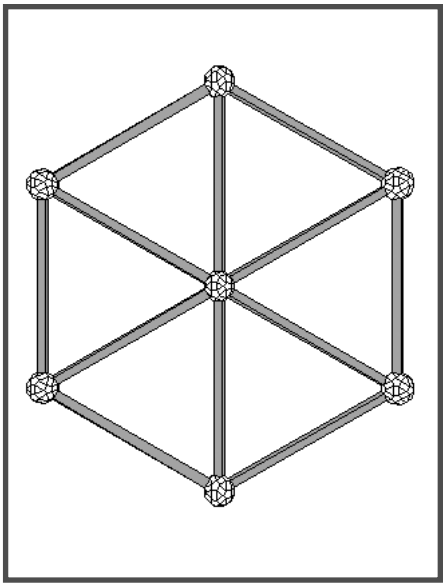
The challenge for the teams is to discover and draw as many different kinds of "special shadows" of their cube models as they can. Explain that you can cast special shadows by putting a long strut into a node in the model and holding it so that the long strut casts the smallest possible shadow (it will be completely blocked by the shadow of the node.)

One way to help students understand this concept is to discuss "no-shadow days" in the tropics. On certain days

of the year you won't cast a shadow if you're standing in the noon-day sun. This can be demonstrated with a globe, a Zome System strut representing someone standing in the tropics and a plane light source like an overhead projector or sunshine. U*nder what conditions do "no shadow days" occur on planet earth? Why does it happen around noon? Is it affected by daylight savings time? Why do you have to be standing up? What is the relationship between the sun's rays and the surface of the earth? What is the relationship between the sun's rays and the person standing outside on a no shadow day? Why do they happen in the tropics? How many times a year do they happen in one place?* Students will learn through experience that the light rays need to be perpendicular to the screen/cardboard and parallel to the strut casting no shadow in order to be effective.



The teams may divide the work, with one team member in charge of putting different color struts in different holes in the cube models, and tracking which combinations have been tried, another casting the shadows, and a third sketching each new shadow in her math journal.
The sun is a very good plane source of light, but it's more difficult to be sure the light rays are perpendicular to the shadow casting surface. Challenge the students to find a way they can be sure the shadow casting surface is perpendicular to the sun's rays. *What if you put one of the shapes you made in the "Shape and Number" class (with the middle strut sticking straight up) flat on the shadow casting surface? When is shadow casting surface perpendicular to the sun's rays? Once the shadow casting surface is perpendicular to the sun's rays, how can it be kept in place?*



Allow 25-30 minutes for this exploration. Circulate and encourage students to find as many different special shadows as they can, making sure they all meet the requirement that a strut inserted in one of the nodes in the cube model casts no shadow. Also encourage teams to classify their findings in a way which will make presentation to the class easier.

When the exploration is over, ask one representative from each team to present their findings. *How many different kinds of shadows could you make with a blue strut? a yel-*

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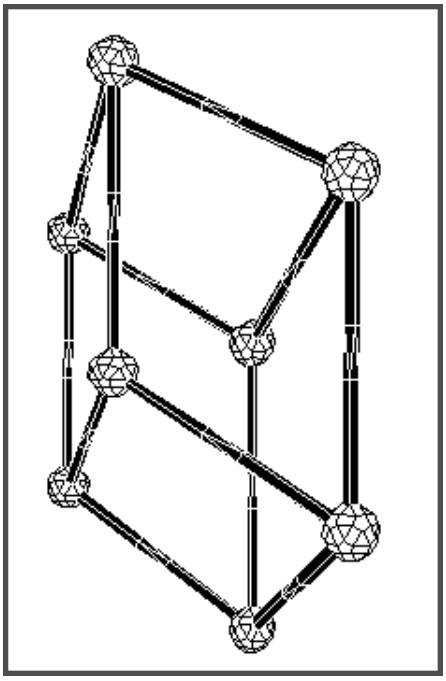
low strut? a red one? Which were the favorite shadows? Why? Is there any relationship between the shape of the strut and the resulting shadow? Some of the students will notice that a Zome System projection along a 2-fold axis of symmetry (blue struts) will often exhibit 2-fold symmetry. Likewise, projections along 3- and 5-fold axes of symmetry (yellow and red struts) will often exhibit 3- and 5-fold symmetries, respectively. While students may not need or even want the vocabulary to describe this discovery, they will certainly gain an intuitive understanding.



Assessment:
Take notes during discussions and presentations, and review drawings of shadows. To meet the standard, students must create and describe a series of shadows of the cube. To exceed the standard, they must correctly identify certain shadows as representing 2-fold and 3-fold symmetries.

Standards Addressed:
* Mathematics standards addressing mathematical connections (NCTM Standard 4).
* Mathematics standards addressing number sense and numeration (NCTM Standard 6).
* Mathematics standards addressing geometry and spatial sense (NCTM Standard 9).
* Physical Science standards requiring students to know and understand common properties, forms, and changes in matter and energy.

Transfer Possibilities:
Continued exploration of symmetry concepts ("Multiple Reflection Symmetry," and "Rotational Symmetry"). Also useful as a starting point for more work on shadows and perspective drawing.