

Sonobe Cube

Instructor Guide

Math concepts/skills:

- Properties of polyhedra
- Congruence
- Angles
- Parallel & perpendicular
- Faces, edges, & vertices
- Surface area

Objective:

- Students will fold a cube and identify the geometric relationships that are present in the completed model.

Vocabulary:

- **Angles:** The amount of turn between two straight lines that have a common end point (the vertex). An angle is measured in degrees.
- **Congruent:** Having exactly the same size and shape.
- **Edge:** The line segment where two faces of a solid meet.
- **Face:** A plane figure that serves as one side of a solid figure.
- **Parallel Lines:** Lines that are always the same distance apart.
- **Perpendicular Lines:** Lines that intersect at right angles to each other.
- **Platonic solid:** A polyhedron with the same regular polygon on every side and also the same number of sides at every vertex.
- **Polyhedron:** A solid with flat faces. From Greek poly – meaning “many” and edron meaning “face”.
- **Right angle:** An angle that measures exactly 90° .
- **Surface area:** The total area of the surface of a three-dimensional object.
- **Vertex:** The point at which two line segments, lines, or rays meet to form an angle.

Supplies:

- 8 x 8 origami paper, students need 6 squares per model in three different colors
- Origami tool
- Student handout
- Origami notebook



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Preparation:

Have a Sonobe cube made prior to this lesson

Videos:

Folding Sonobe Unit:

<https://www.youtube.com/watch?v=TKGW2W168H0>

Assembling Sonobe Cube:

<https://www.youtube.com/watch?t=23&v=WasvUFXmACk>

Background:

This lesson uses a technique called *modular origami*. Modular origami is a technique that can be used to build some pretty interesting and impressive models of mathematical objects. In modular origami, a geometric figure is folded from a single sheet of paper. The folding sequence used to fold the figure is repeated with several more sheets of paper to produce a collection of identical units, or modules. These units fit together to form a model. The model might be a polyhedron such as a cube, an icosahedron, or it might be a two-dimensional star.

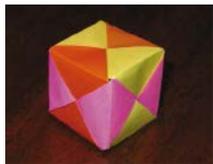
Modular origami is relatively new type of origami. Tomoko Fuse of Japan is credited with its creation and has created many unit origami models. Her work has inspired many other folders to use origami to model polyhedral.

The Sonobe cube is made from six Sonobe units. The Sonobe unit is one of the simple origami units that can be used to create beautiful polyhedral. The design is a parallelogram with two tabs and two “pockets.” Into these pockets, corresponding tabs of other Sonobe units can be inserted.

Procedure:

Show students a completed cube and ask students to think about how it might be constructed. How many pieces of paper did it require? Give time for students to call out their ideas. This will help student to focus on the origami project and the “big picture” before actually folding by thinking about the process it took to create the cube.

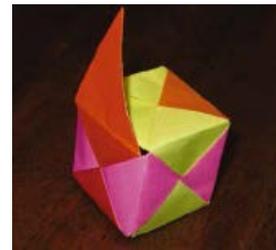
Ask students what information they would need to feel sure of their prediction. Would they need to see the whole cube taken apart or maybe only see part of it?



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Begin to deconstruct the cube and carefully pull out a part of one of the six pieces. Ask if anyone would like to reevaluation or change their prediction.



Continue to deconstruct the cube and lay out the six pieces.

Discuss:

- Are the pieces rhombuses or parallelograms?
- Look at the rotational symmetry and congruence of the units. Test by stacking the pieces on top of one another.
- Faces, edges, vertices, intersections, parallel and perpendicular lines.

Now that the cube is disassembled, challenge students to think about putting it back together. Work your way back to what must be the first step and form a plan.

Create a step-by-step series of instructions for students to follow. Now, students are ready to begin folding!



Pass out the supplies. Each student will need six sheets of paper in three different colors.

If students ask for help, challenge them to reflect. Instead of helping them right away, direct them to the instructions or to what others are doing. Ask which step is confusing. Many times it is just a matter of helping students orientate their paper like the model to determine the next step.



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When all students have successfully constructed a cube, have them get into small groups and work together to answer the questions on the handout.

When groups have finished, close with a class discussion.

Extensions:

1. Determine the relationship between the size of the original square and the dimensions of the finished cube.
2. Students can try and make some other cube-related shapes that can be made using the same basic units. For example, colliding cubes can be made with 9, 12, & 18 units.