In this lesson, students will build a functional 2x2 Rubik’s Cube out of paper.

**Texas Essential Knowledge & Skills (TEKS):**

**Mathematics 3.7E Geometry and measurement.**
The student applies mathematical process standards to select appropriate units, strategies, and tools to solve problems involving customary and metric measurement.
(E) The student is expected to: determine liquid volume (capacity) or weight using appropriate units and tools

**Mathematics 5.6A-B Geometry and measurement.**
The student applies mathematical process standards to understand, recognize, and quantify volume. The student is expected to:
(A) recognize a cube with side length of one unit as a unit cube having one cubic unit of volume and the volume of a three-dimensional figure as the number of unit cubes (n cubic units) needed to fill it with no gaps or overlaps if possible;
(B) determine the volume of a rectangular prism with whole number side lengths in problems related to the number of layers times the number of unit cubes in the area of the base

**Mathematics 7.9D Expressions, equations, and relationships.**
The student applies mathematical process standards to solve geometric problems. The student is expected to:
(D) solve problems involving the lateral and total surface area of a rectangular prism, rectangular pyramid, triangular prism, and triangular pyramid by determining the area of the shape’s net

**Mathematics 8.7B Expressions, equations, and relationships.**
The student applies mathematical process standards to use geometry to solve problems. The student is expected to:
(B) use previous knowledge of surface area to make connections to the formulas for lateral and total surface area and determine solutions for problems involving rectangular prisms, triangular prisms, and cylinders;

**Mathematics Process Standards K-12**
The student uses mathematical processes to acquire and demonstrate mathematical understanding. The student is expected to:

1A apply mathematics to problems arising in everyday life, society, and the workplace.
1C select tools, including real objects, manipulatives, paper and pencil, and technology as appropriate, and techniques, including mental math, estimation, and number sense as appropriate, to solve problems.
ELA 1-5.1B Developing and sustaining foundational language skills: listening, speaking, discussion, and thinking--oral language. The student develops oral language through listening, speaking, and discussion. The student is expected to:

(B) follow, restate, and give oral instructions that include multiple action steps.

Engineering Design & Problem Solving (CTE) - 130.412.5A-E, I

The student applies knowledge of science and mathematics and the tools of technology to solve engineering design problems. The student is expected to:

(A) apply scientific processes and concepts outlined in the Texas essential knowledge and skills (TEKS) for Biology, Chemistry, or Physics relevant to engineering design problems;

(B) apply concepts, procedures, and functions outlined in the TEKS for Algebra I, Geometry, and Algebra II relevant to engineering design problems;

(C) select appropriate mathematical models to develop solutions to engineering design problems;

(D) integrate advanced mathematics and science skills as necessary to develop solutions to engineering design problems;

(E) judge the reasonableness of mathematical models and solutions;

(I) make measurements with accuracy and precision and specify tolerances;

130.412.4D-E

The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to:

(D) evaluate the impact of scientific research on society and the environment;

(E) evaluate models according to their limitations in representing biological objects or events.
**Objectives:**
Students will plan, measure, and follow directions to build a 2x2 model of a Rubik’s Cube.

**Materials:**
- 2x2 Rubik’s Cubes (1 per student)
- Colored paper - red, blue, yellow, green, orange
- String (18" per student)
- Heavy duty tape (packing tape)
- Scissors (1 per student)
- Glue sticks

**Background Knowledge:**
*Helpful, but not essential:*
Students should understand how a net can be folded to create three-dimensional polyhedron. Students should understand that the template net is not the only configuration of a net that will create a cube.

**Procedure:**
**Beforeclass:**
- Copy cube template page
  *each student will need 4 sheets (2 cube templates per sheet)*
- Cut strings about 4.5 inches long
  *each student will need 4 strings*
- Make a sample of the project to show the students

**Part 1: What is Engineering?**
1. Discuss *engineering* with students. What is engineering? What is the purpose of engineering? While some people have stumbled upon great ideas, others set about trying to solve real-world problems.
2. Define the main branches of engineering: electrical, mechanical, chemical, and civil. Work with the class to come up with examples of things each type of engineer might build.

3. Students can learn about accidental inventions through the short stories in the book, *Mistakes That Worked*, by Charlotte Hone, et.al. Share a few of the stories with students.

**Part 2: Examine the 2x2x2 Rubik’s Cube**

1. Give students exploration time with the 2x2 Rubik’s Cube. Ask: What are the similarities and differences between the 3x3 and 2x2 Rubik’s Cube? Why are they called “3x3” (three-by-three) and “2x2” (two-by-two)?

2. Determine the perimeter and area of each face and the surface area and volume of the 2x2 cube with students.

3. Identify the shapes and angles that make up the cube.

4. Define **net** in mathematics. (a two-dimensional figure that can be folded into a three-dimensional object)

5. Work through the interactive problems on the Illuminations website where students will identify which 2D nets can be folded into cubes. 

**Part 3: Build a 2x2x2 Rubik’s Cube**

1. Now, students will follow directions to make a functional paper model of a 2x2x2 Rubik’s Cube. Show students the sample 2x2 cube they will be making.

2. Students will measure and cut 4 squares 1.25 inches on each side of each color.

3. Glue colored squares onto the appropriate spaces for each corner piece. You may want to show
students where the colors should go, or have them examine the 2x2 cubes to determine the placement.

4. Cut out each cube template and fold on solid lines to create 8 cubes. *Students could also create their own cube nets, but the template will help expedite the activity

5. Students can use glue sticks or tape on the tabs to create the cubes. Covering the cubes in clear packing tape will help make the pieces more durable.

6. Attach strings (with clear packing tape) diagonally on pairs of cubes in the upper and lower layers of the cube. *See photo

7. Twist the cube to ‘tangle’ the strings-creating a working 2x2 Rubik’s Cube model!
**Technology Connection:**

Online resources for learning to solve the 2x2 Rubik’s Cube:  
https://www.youcandothecube.com/solve-it/2-x-2-solution

Activity where students determine which nets will create cubes:  
https://illuminations.nctm.org/activity.aspx?id=3544

If you choose to make the pieces out of origami cubes, demonstrations are available online:

- Modular cube using 6 pieces of paper per cube, easy to fold, but will require 48 modules:  
  https://www.youtube.com/watch?v=6qktujAMcV8&t=2s
- Cube made from single piece of paper, more difficult fold:  
  https://www.youtube.com/watch?v=cDvHp_hg25Q&t=10s=

**Optional Follow Up / Extend the Lesson**

Using the *You Can Do the Rubik’s Cube* Rubik’s Cube Solution Guide or online videos, students can learn to solve the 2x2 cube.

Depending on the class time you have available, and skill level of your students, you can increase the difficulty on the project by having the students make origami cubes rather than using the cube templates.

You can also make the project a bit quicker by having the colored squares precut for the students.

2x2 Rubik’s Cubes are available to borrow from the *You CAN Do the Rubik’s Cube* Lending Program at no cost other than return shipping.  
www.youcandothecube.com/lending-library

This lesson is an adaptation of *Engineering & Construction: Solving Real-World Problems*, developed by STEM.org for You CAN Do the Rubik’s Cube.