LEARN TO SOLVE THE RUBIK’S® CUBE

You CAN do the Rubik’s CUBE

The WHITE Cross

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## 21st Century Learning Skills

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### GOAL: The WHITE Cross

The goal of this stage is to get the WHITE cross on the UP face with all the colored sides of the WHITE edges matching the center pieces.
# CONTENT STANDARDS & SKILLS: LESSON 2

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<th>Grade</th>
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| K-2   | K.G.1 Names of shapes  
1.G.1 Defining attributes of shapes  
1.OA.B.3 Apply properties of operations as strategies | **Geometry**  
- describe attributes and parts of two- and three-dimensional shapes  
- create mental images of geometric shapes  
- recognize shapes from different perspectives  
- relate ideas in geometry  
- recognize geometric shapes in the environment |
| 3-5   | 3.OA.B.5 Apply properties of operations as strategies  
4.OA.C.5 Generate a number or shape pattern that follows a given rule. Identify apparent features of the pattern that were not explicit in the rule itself.  
4.G.1 Identify angles, perpendicular and parallel lines in two-dimensional figures | **Number and Operations**  
**Geometry**  
- identify attributes of two- and three-dimensional objects; develop vocabulary to describe the attributes  
- describe objects and patterns  
- recognize geometric ideas and apply them in the classroom and everyday life |
| 6-8   | 6.EE.A.3 Apply the properties of operations to generate equivalent expressions.  
6.EE.A.4 Identify when two expressions are equivalent  
7.EE.A.2 Understand that rewriting an expression in different forms in a problem context can shed light on the problem and how the quantities in it are related.  
8.G.A.1 Verify experimentally the properties of rotations, reflections, and translations. | **Geometry**  
- precisely describe two- and three-dimensional objects using their attributes |
The questions on these slides are meant to focus students on the characteristics of the Rubik’s Cube. Depending on the grade level of your students, these questions may or may not be appropriate. Many of the slides are animated so what you see in this guide may not appear all at once in the presentation.

Each lesson in this series begins with a review of the previous lesson and ends with a review of the current lesson. The review of the current lesson is always followed by a math extension which may or may not apply to your grade level. The last slide in each lesson is a trivia question. Please modify your presentation to best meet the needs of your students.

**Review: Slides 3 - 7**

As you review the parts of the cube, emphasize the orientation (i.e. the FRONT face faces you) and how this differs from the color of the faces which is determined by the CENTER tile. The EDGE pieces will be the focus of the WHITE Cross so make sure students can readily identify those pieces.

**Reviewing EDGE Pieces**

Pieces with two colors.

How many edge pieces are there on a Rubik’s Cube?

Edge pieces are between the...

**Reviewing CORNER Pieces**

Pieces with 3 colors.

How many corner pieces are there?

Why do they have 3 colors?

**HINT:** Have students place their flat palms on the face you want them to turn. This is a good strategy to use at any stage of solving the cube.

**HINT:** Keeping the cube on the table or desk may help students attend to the orientation of the cube which is an important concept as they solve.
In order to solve a Rubik’s Cube, it must first be scrambled. A **scramble** is 25 random ¼ turns.

Have the students look at the sequence. Notice that there are no adjacent moves that are opposites of one another. (Ri never follows R.) Have students explain why this is true.

The difference between **layers** and **faces** can be confusing. The cake analogy may help. Layers of the cube are like layers of a cake. Faces on the cube are the frosting on the cake.

In this lesson, talking about the layers is an intermediary step to getting the WHITE tiles on the UP face. This will probably make more sense in the next series of slides.
These slides are an opportunity to think purposefully about how the cube moves. The number of tiles on a piece determines the number of faces you can turn to move that piece. The focus here is on Edge pieces which are what you will need to make the WHITE Cross.

Where does the WHITE tile go when you make a F turn? The WHITE tile will go to the BOTTOM layer on the FRONT face.

When you make a Fi turn (on the original diagram), the WHITE tile will be on the TOP layer on the FRONT face.

Fi was a better move than F because the WHITE tile is on the TOP layer, but neither turn put the WHITE tile on the UP face.

Making an R turn will put the WHITE tile on the UP face, next to the YELLOW Center.

Have students determine how to get the:
- GREEN tile of the GREEN / RED Edge piece on the UP face. (F turn)
- RED tile of the GREEN / RED Edge piece on the UP face. (Li turn)
- YELLOW tile on the BOTTOM layer of the LEFT face (either Li F or L B) Another way of moving this tile is shown on slide 16.

There are many resources that state that making the daisy is intuitive. While many solvers find it fairly easy, slides 15 & 16 offer some tips for those who are getting stuck. If students are still struggling, go back to slides 11 & 12 to get a better feel for how the Edges move.
PART 1: Making the Daisy

- Hold the cube with the **YELLOW** center on the UP face.
- Find an Edge piece that has a **WHITE** tile.
- Turn the face without the **WHITE** tile until the **WHITE** tile is on the UP face.
- Repeat these steps until all 4 **WHITE** Edge tiles are on the UP face.

HINT: Students may need to turn the TOP layer before moving an Edge piece so that they don't lose a **WHITE** tile that is in the correct position.

To make the Daisy, the **YELLOW** face must be the UP face. Now that you have the **YELLOW** Center, you need the **WHITE** petals.

Using what they learned about how Edge pieces move, students will locate the Edge pieces with **WHITE** tiles and put the **WHITE** tiles on the UP face surrounding the **YELLOW** Center.

Sometimes, the Edge piece is moved to the TOP layer but the **WHITE** tile is not on the UP face. This algorithm for "flipping an edge" is a handy one to know.

You might have students follow the algorithm for any Edge piece and then repeat the algorithm to see how the Edge piece returns to its original state. This may give them a better sense of what the algorithm does as well as extra practice executing the algorithm.
The daisy is on the UP face for Part 2. It doesn't matter which Edge you choose first. The important step is to match the non-WHITE tile of the Edge piece to its matching Center tile. In the example given, the ORANGE Edge tile is matched to its ORANGE Center by turning the UP face.

Once the non-WHITE Edge is matched with its Center, 2 turns of that face (in the example, the ORANGE face) will move the WHITE tile to the DOWN face.

One at a time, match Edges to Centers and make 2 turns for each 4 the Edge pieces surrounding the YELLOW Center.

**HINT:** Have students place the flat of their palm on the face with the matching Edge & Center. This will help them know which face to turn.
Review: Slides 22 - 24
These slides could be printed as a reference for students, perhaps in a learning center.

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Math Connection: Slide 28

Lesson Extension
How does this lesson apply to math?
The sequence Ri, U, F, Ui is an algorithm.
- An algorithm is a set of rules or set of steps that we use to solve math problems.
- For example, when we multiply 45x12:
  - First multiply 45 by 2.
  - Then multiply 45 by 10.
  - Last, add the two products together.

Vocabulary: Slides 29 - 30

Vocabulary
- **Cube**: 3 dimensional object with 6 square faces
- **Face**: 2 dimensional surface or side of a cube
- **Center**: The piece in the middle of a face. Face colors are the color of the center.
- **Corner**: The piece where 3 faces meet

Vocabulary
- **Edge**: The piece where 2 small tiles on different faces meet
- **Turn (move)**: A 1/4 clockwise turn of a face of the Cube. A turn is 90°.
- **Layer**: 3 dimensional slice of a Rubik’s Cube
- **Inverse**: An opposite action. The inverse of a move “undoes” the move.

Trivia: Slide 31

Reading large numbers and rounding to a specific place are great math connections here, too.

Question: If someone gave you a dollar for each of the possible combinations on a Rubik’s® Cube, how much money would you have?

Answer: There are 43 quintillion combinations so you would have $43 quintillion.
(43,252,003,274,489,856,000)

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SCRAMBLING PRACTICE

Use the following sequences to practice scrambling your Rubik’s Cube.

Sequence A - Will everyone’s Cube look the same after this scramble? Why or why not?

Sequence B

Sequence C - Record your own 25 turns to scramble a Rubik’s Cube.

____     ____     ____     ____     ____     ____     ____     ____     ____     ____     ____     ____
____     ____     ____     ____     ____     ____     ____     ____     ____     ____     ____     ____
____

Any 25 turns of a Rubik’s Cube is called a scramble. The goal is to mix the cube up as much as possible. Some scrambles might be better than others. What would be a bad scramble? Why?
How well do you know the cube?

Here’s a Rubik’s Cube with a completed WHITE CROSS. The gray tiles could be any of the Rubik’s Cube colors. It doesn’t matter for this activity.

Color the cube below so that it shows what the hidden faces of the Rubik’s Cube above look like.
QUARTER TURN REFERENCE SHEET

R  Ri  L  Li
D  Di  U  Ui
B  Bi  F  Fi
Thank you to Tyson Mao, Jasmine Lee, and Dan Harris for your inspiration to this guide. Thank you to all of the Daisy Method contributors.

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