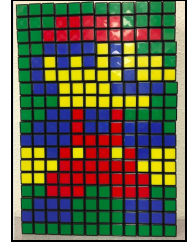


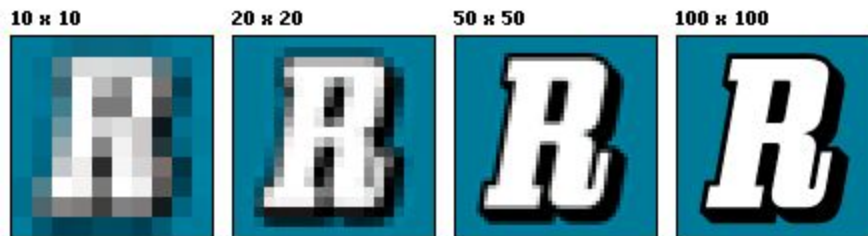
Creating a Rubik's® Cube Mosaic: Making a Multi-colored Cross

All digital images are composed of millions of squares or pixels. Students may be familiar with Minecraft or photographs where faces are blurred out. Both of these are examples of enlarging the pixels, resulting in lower resolution. The better the resolution of the image the more pixels per square unit. Creating mosaics using Rubik's® Cubes is a great lesson in resolution and area.



YCDTRC Mosaic Contest
1st place- 24 Cubes
San Luis Middle School

Below is an example of improving resolution as the number of pixels per square unit increases.



https://en.wikipedia.org/wiki/Image_resolution

In this lessons, students will learn how to solve the cross or + on the upper face of the Rubik's® Cube to a given pattern

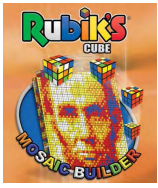
The pages that follow may be individual lessons of 10 - 15 minutes or stations in your classroom. Each student page is followed by a Teacher Notes page.

Standards Addressed in this Lesson:

According to the National Coalition for Core Arts Standards (<http://www.nationalartsstandards.org>), students use critical thinking and problem solving skills in creating and analyzing art. Art is a unique method of communication. More information about art standards can be found at <http://www.nationalartsstandards.org/content/conceptual-framework>.

Common Core Mathematical Practices:

- 1 Make sense of problems and persevere in solving them.
- 2 Reason abstractly and quantitatively.
- 3 Construct viable arguments and critique the reasoning of others.
- 6 Attend to precision
- 7 Look for and make use of structure



Creating a Rubik's® Cube Mosaic: Making a Multi-colored Cross

Materials:

A Rubik's® Cube for each student

Handout for each student or group

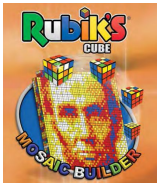
Rubik's® Turn Cards (Memory Game): **Make several copies for each student.**

You may want to cut them out, glue them to index cards, and laminate them.

red, green, blue, yellow, orange colored pencils, markers, or crayons

Background knowledge:

Students should be familiar with the vocabulary of the Rubik's® Cube (edge, corner, center cubes and upper, down, front, back, left & right faces). They should understand that one turn of the cube in any given direction is a 90° turn.



Creating a Rubik's® Cube Mosaic: Making a Multi-colored Cross

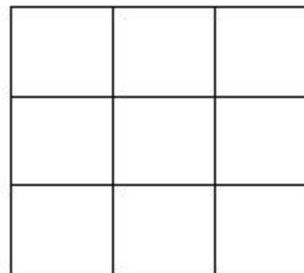
Mosaics are pictures or designs that are made up of small pieces, usually glass, stone, or tile. Maybe you've made a mosaic out of paper or even elbow macaroni! In these lessons, you will learn to use Rubik's® Cubes to make mosaics. First, you will solve one face of the cube. Once you learn the pattern, you can make wonderful pieces of Rubik's® art.

You and your classmates are going to start with a solved Rubik's® Cube so everyone will get the same results. After you learn the moves, it won't matter whether or not you start with a solved cube.

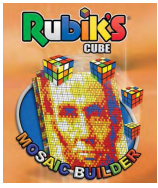
We are going to change the top or upper face to make this pattern:



First, we are going to make "the cross" or + part of the pattern. Color the cross or + we are making (from the upper face of the cube) on the grid below.



- How should you hold the cube? What color will be on the upper face? How do you know?
- Will any of the edge pieces be in the correct position? How do you know?



Creating a Rubik's® Cube Mosaic: Making a Multi-colored Cross

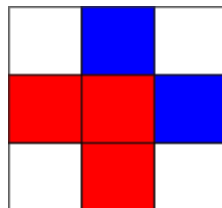
Teacher Notes: In this series of lessons, students will focus on the upper face edge pieces. They will learn how to “flip” the edge pieces so that the top square swaps places with the lateral square. Encourage students to use the Rubik's® turn cards as they complete the activity. This will make it easier to “undo” their steps at the end of the lesson.

Mosaics are pictures or designs that are made up of small pieces, usually glass, stone, or tile. Maybe you've made a mosaic out of paper or even elbow macaroni! In these lessons, you will learn to use Rubik's® Cubes to make mosaics. First, you will solve one face of the cube. Once you learn the pattern, you can make wonderful pieces of Rubik's® art.

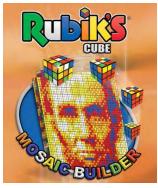
You and your classmates are going to start with a solved Rubik's® Cube so everyone will get the same results. After you learn the moves, it won't matter whether or not you start with a solved cube.

We are going to change the top or upper face to make this pattern:

First, we are going to make “the cross” or + part of the pattern. Color the cross or + we are making (from the upper face of the cube) on the grid below.



- How should you hold the cube? What color will be on the upper face? How do you know? **The upper face should be red because the middle square is red. The middle square can't be moved by turning a face so it must be the correct color when starting to make the mosaic.**
- Will any of the edge pieces be in the correct position? How do you know? **Two edge pieces will be in the correct position because there are two red edge pieces in the design.**



Creating a Rubik's® Cube Mosaic: Making a Multi-colored Cross

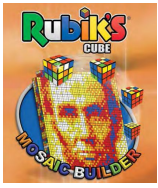
For now, we don't care about the corner pieces. Two blue squares need to be put on the upper face. There are many ways to do this. One way is to hold the cube so that the blue face is the right face, like this:

The front face will be yellow.

- Find the the **red/blue** edge piece. On which face does the **blue square** of the **red/blue edge** piece wind up when you turn the right side toward you (counterclockwise turn)?

Front Back Upper Down Left Right

- Turn the right side toward you again. Where is the **blue square** on the red/blue edge piece now?
- What turns should you make to move the **red/blue edge** piece back to the top layer of the right face? Write the turns here.
- Follow the directions you wrote. Were you correct?
- Share your directions with a classmate. Are they the same?
- Is there someone in class who has different directions that also work? Why?



Creating a Rubik's® Cube Mosaic: Making a Multi-colored Cross

Teacher Notes: Encourage students to use the Rubik's® turn cards as they complete the activity. This will make it easier to "undo" their steps at the end of the lesson.

For now, we don't care about the corner pieces. Two blue squares need to be put on the upper face. There are many ways to do this. One way is to hold the cube so that the blue face is the right face, like this:

The front face will be yellow.

- Find the the **red/blue** edge piece. Where does the **blue square** on the red/blue edge piece wind up when you turn the right side toward you (counterclockwise or a right inverted turn)?

Front Back Upper Down Left Right

The blue square remains on the right face but moves from the top layer to the left side.

- Turn the right side toward you again. Where is the **blue square** on the red/blue edge piece now? **Right face but now on the bottom layer.**
- What turns should you make to move the red/blue edge piece back to the top layer of the right side? Write the turns here. **Either turn the**

right face away from you twice



thus "undoing" what you have

done or turn the right face toward you twice

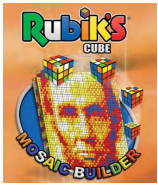
thus

turning the right side 360°.



This might be a good place to introduce students to the inverted notation. The Rubik's® Cube Solution Guide always turns a face clockwise. Note that the "active" face, the one being turned, is white, while the inactive faces are greyed out. The letter *i* following the turn notation means inverted or inverse. R, a counter-clockwise turn, would be the inverse or opposite of Ri, a clockwise turn. Notice that the color coding - teal for clockwise, blue for the inverted.





Creating a Rubik's® Cube Mosaic: Making a Multi-colored Cross

- Follow the directions you wrote. Were you correct?

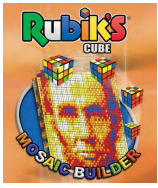
You may want to give students a set of Rubik's® turn cards so that they can make a sequence of turns with the cards, check to see if they work, and then record their results. Answers will vary. Encourage students to find the most efficient method, either of the two described above.

- Share your directions with a classmate. Are they the same?

The directions may differ. Encourage students to explain to one another why differing methods work or to brainstorm to find another method that will work.

- Is there someone in class who has different directions that also work? Why? Lots of good explanations are possible here. The student could be working backwards and having to do the opposite turn, again an opportunity to take about the inverted notation of the Rubik's® Cube Solution Guide. The student could talk about turning half a circle, two halves make a whole so you'd wind up in the starting position, maybe making a ferris wheel analogy. You could have students act out the turns with their bodies.

Have students “undo” their directions so that the Rubik's® Cube is returned to a solved state before beginning the next page.



Creating a Rubik's® Cube Mosaic: Making a Multi-colored Cross

Hold your solved cube so the upper face is red and the right face is blue. What color is the front face?

Why is it that color?

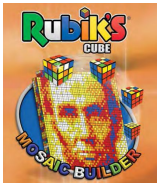
- Find the **red/blue edge** piece. Turn the upper face one turn to the right (clockwise), as if you are closing a jar. Where is the **blue square** on the red/blue edge piece now?

Front Back Upper Down Left Right

- Without turning the cube yet, predict where the **blue square** on the red/blue edge will be if you turn the upper face again one turn to the left.
- Now make that one turn. Were you correct?
- Turn the upper face twice to the left (counterclockwise or U inverted), as if you are opening a jar. Where is the **blue square** on the red/blue edge now?
- Where will the red/blue edge be if you follow these directions?

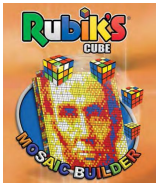
then

- Predict which turns should you make to put the red/blue edge back where it was when we started this page. Record your turns here.



Creating a Rubik's® Cube Mosaic: Making a Multi-colored Cross

- Follow the directions you wrote. Were you correct?
- Share your directions with a classmate. Are they the same?
- Is there someone in class who has different directions that also work? Why?



Creating a Rubik's® Cube Mosaic: Making a Multi-colored Cross

Teacher Notes: Encourage students to use the

Rubik's® turn cards as they complete the activity. This will make it easier to "undo" their steps at the end of the lesson.

Hold your solved cube so the upper face is red and the right face is blue. What color is the front face? **yellow**

Why is it that color? Here is a good place to remind students about the color characteristics of the cube, especially the center square. The red face is always opposite the orange face; blue, opposite green; yellow, opposite white. The blue face is always adjacent to the yellow and white (in this case left and right of blue) and red and orange (in this case, upper and bottom to blue).

- Find the **red/blue** edge piece. Turn the upper face one turn to the right (clockwise), like you are closing a jar. Where is the **blue square** on the red/blue edge?

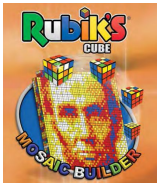
Front Back Upper Down Left Right

Have students articulate that now the blue is in the top row or layer of the front face whereas the Ri turn on the previous page put the blue square in the left column or side of the right face.

- Without turning the cube yet, predict where the **blue square** on the red/blue edge will be if you turn the upper face again one turn to the left. **Left face**
- Now make that one turn. Were you correct?
- Turn the upper face twice to the left (counterclockwise or U inverted), like you are opening a jar. Where is the **blue square** on the red/blue edge now? **Right face, back in the original position because you made opposite turns**
- Where will the red/blue edge be if you follow these directions?

then The U turn does not move the red/blue edge from the position it was in after the Ri move.

- Predict which turns should you make to put the red/blue edge back where it was when we started this page. Record you turns here.



Creating a Rubik's® Cube Mosaic: Making a Multi-colored Cross

Although there may be many correct answers, the most efficient are to

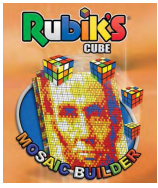


“undo” the previous moves by turning then .

Encourage students to use the Rubik's® turn cards as needed. Look for the most efficient methods.

- Follow the directions you wrote. Were you correct?
- Share your directions with a classmate. Are they the same?
- Is there someone in class who has different directions that also work? Why?

Have students “undo” their directions so that the Rubik's® Cube is returned to a solved state before beginning the next page.



Creating a Rubik's® Cube Mosaic: Making a Multi-colored Cross

Hold your solved cube so the upper face is red and the right face is blue. Will everyone have the same color on the front face?

- Turn the front face one turn to the left, as if you are turning a doorknob backwards (counterclockwise or F inverted). Where is the **blue square** on the **red/blue edge** piece?

Front Back Upper Down Left Right

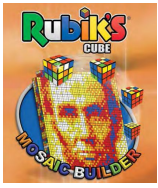
Where is the **blue square** on the **yellow/blue edge**?

Front Back Upper Down Left Right

- Without turning the front face again one turn to the left, predict where will the **blue square** on the **red/blue edge** be.

Predict where the **blue square** on the **yellow/blue edge** will be.

- Now make that one turn. Were you correct?
- Turn the front face twice to the right (clockwise), as if you are opening a door. Where is the **blue square** on the **yellow/blue edge** now?



Creating a Rubik's® Cube Mosaic: Making a Multi-colored Cross

Teacher Notes: Encourage students to use the Rubik's® turn cards as they complete the activity. This will make it easier to "undo" their steps at the end of the lesson.

If this is NOT day 2 of the lesson, you may want to omit the next question. Hold your solved cube so the upper face is red and the right face is blue. Will everyone have the same color on the front face? Have students explain why everyone will have the same color front face. (Review opposite faces color connection.)

- Turn the front face one turn to the left, as if you are turning a doorknob backwards (counterclockwise or F inverted). Where is the **blue square** on the **red/blue** edge piece?

Front	Back	Upper	Down	Left	Right
				Fi here does not move the red/blue edge	

- Where is the **blue square** on the **yellow/blue** edge?
Front Back Upper Down Left Right

- Without turning the front face again one turn to the left, predict where will the **blue square** on the **red/blue edge** be.

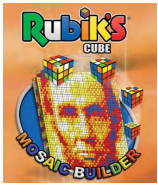
Predict where the **blue square** on the **yellow/blue edge** will be.

Although this might be a bit repetitive, the purpose is to reinforce which cubes move and which do not. The red/blue edge does not move. The blue square on the yellow/blue edge will be on the right side of the left face.

- Now make that one turn. Were you correct?
- Turn the front face twice to the right (clockwise), as if you are opening a door. Where is the **blue square** on the **yellow/blue** edge now? Back in its original position as you are "undoing" the previous moves. The inverse of Fi is F.
- Where will the **blue square** on the **red/blue edge** be if you follow these directions?

then then

Upper face



Creating a Rubik's® Cube Mosaic: Making a Multi-colored Cross

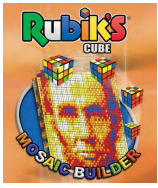
- What do you notice about the **red/blue** edge?

The blue square is now on the upper face instead of the lateral (side) face. The red square is now on the lateral face instead of on the upper face. The edge piece has “flipped.”

- What turn should you make to put the **blue square** on the **red/blue** edge on the left side of the upper face of the Rubik's® Cube?

Turn the upper face to the right, U_i , (counterclockwise) as if you were closing a jar.

Have students “undo” their directions so that the Rubik's® Cube is returned to a solved state before beginning the next page.

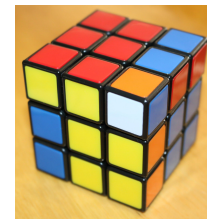


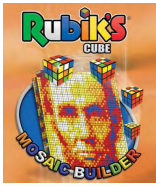
Creating a Rubik's® Cube Mosaic: Making a Multi-colored Cross

Start with a solved Rubik's® Cube. What turns will you need to make to create this design on your cube? Record your turns here.



- Because we started with a solved cube, there is an easy way to put another blue square in the correct position. Predict which turn or turns should you make. Record your turn(s) here.
- Follow your directions. Were you correct?
- Share your directions with a classmate. Do you have the same directions?
- Is this the correct position for the second blue square? Explain your reasoning.
- What turn(s) should you make to “undo” your directions so the cubes goes back to looking like this?





Creating a Rubik's® Cube Mosaic: Making a Multi-colored Cross

Teacher Notes: Encourage students to use the Rubik's® turn cards as they complete the activity. This will make it easier to "undo" their steps at the end of the lesson.



Start with a solved Rubik's® Cube. What turns will you need to make to create this design on your cube? Record your turns here.



- Because we started with a solved cube, there is an easy way to put another blue square in the correct position. Predict which turn should you make. Record your turn here. Turn left face away from you, **Li**, (counterclockwise) **or** Back face to the left, **B**, (clockwise - imagine a clock on the back face as you turn). You may want to offer students the Rubik's® turn cards.

- Follow your directions. Were you correct?

Answers may vary.

- Share your directions with a classmate. Do you have the same directions?

Answers may vary.

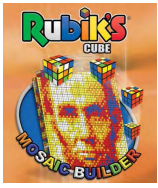
- Is this the correct position for the second blue square? Explain your reasoning.

If the turn was **Li**, then the blue square is **not** in the correct position. The blue/white edge is opposite the blue/red edge. A blue edge piece need to be a consecutive face to the blue/red edge so **B** is the turn the makes consecutive blue edges on the upper face.

- What turn should you make to "undo" your directions so the cubes goes back to looking like this? **L** or **Bi**



Have students "undo" all their directions so that the Rubik's® Cube is returned to a solved state before beginning the next page.



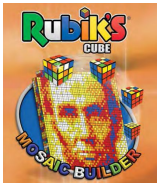
Creating a Rubik's® Cube Mosaic: Making a Multi-colored Cross

Let's investigate turning the front face to see how it will help put a blue square in the correct position. Start with a solved Rubik's® Cube. Hold the cube so the upper face is red and the front face is yellow.

- Find the **red/yellow** edge. Turn the front face one turn to the right, F, (clockwise), as if you were turning a doorknob. Where is the **red square** on the red/yellow edge now?

Front Back Upper Down Left Right

- Predict where the **red square** on the red/yellow edge will be if you turn the front face again one turn to the right, F.
- Now make that one turn. Were you correct?
- Find the **yellow/blue** edge. Turn the front face twice to the left, Fi, (counterclockwise), as if you are turning a doorknob backwards. Where is the **blue square** on the yellow/blue edge now?



Creating a Rubik's® Cube Mosaic: Making a Multi-colored Cross

- Predict where will the **blue square** on the **yellow/blue** edge be if you follow these directions.

then

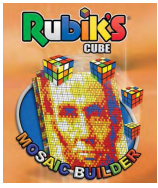
then

then

then

- Follow the directions above. Were you correct?
- Where is the **blue square** on the **blue/red** edge?

- What turn should you make to put the **blue square** on the yellow/blue edge on the upper face of the Rubik's® Cube?



Creating a Rubik's® Cube Mosaic: Making a Multi-colored Cross

Teacher Notes: Encourage students to use the Rubik's® turn cards as they complete the activity. This will make it easier to "undo" their steps at the end of the lesson.

Let's investigate turning the front face to see how it will help put a blue edge piece in the correct position. Start with a solved Rubik's® Cube. Hold the cube so the upper face is red and the front face is yellow.

- Find the **red/yellow** edge. Turn the front face one turn to the right (clockwise), as if you were turning a doorknob. Where is the **red square** on the red/yellow edge now?

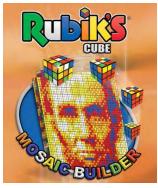
Front Back Upper Down Left **Right**

- Predict where the **red square** on the red/yellow edge will be if you turn the front face again one turn to the right. **Down**
- Now make that one turn. Were you correct?
- Find the **blue square** on the **yellow/blue** edge. Turn the front face twice to the left (counterclockwise or F inverted), as if you are turning a doorknob backwards. Where is the yellow/blue edge now? **Left side of the right face**
- Predict where will the **blue square** on the yellow/blue edge be if you follow these directions. **Left side of front face**

then then then then

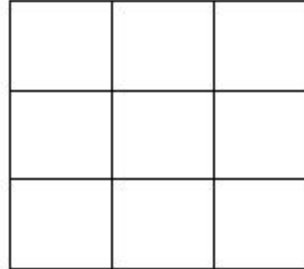
- Follow the directions above. Were you correct? **Answers may vary.**
- Where is the **blue square** on the **blue/red** edge? **On the right side of the upper face**
- What turn should you make to put the **blue square** on the yellow/blue edge on the upper face of the Rubik's® Cube? **Fi Students might note that the cross pattern they have been making is now on the upper face, although the corner pieces are different.**

Have students "undo" their directions so that the Rubik's® Cube is returned to a solved state before beginning the next page.



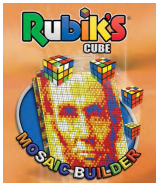
Creating a Rubik's® Cube Mosaic: Making a Multi-colored Cross

Color a new cross or + pattern on the upper face grid below. It doesn't matter what color the corner pieces are so leave them blank.



What turns should you make to create your pattern on the Rubik's® Cube?

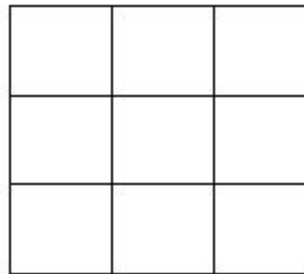
Record your moves here.



Creating a Rubik's® Cube Mosaic: Making a Multi-colored Cross

Teacher Notes: Encourage students to use the Rubik's® turn cards as they complete the activity. This will make it easier to "undo" their steps at the end of the lesson.

Color a new cross pattern below. It doesn't matter what color the corner pieces are so leave them blank.

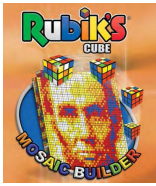


What turns should you make to create your pattern on the Rubik's® Cube? Answers will vary. Have students use the Rubik's® turn cards to help them plan. Perhaps they will work in pairs. There should be variations of the



sequence **Ri** then **U** then **Fi** then **Ui** to position each edge piece. This sequence generally takes an edge piece on the upper layer and flips the piece so that the upper square of the edge piece swaps position with the lateral square. Encourage students to work in chunks, one edge piece at a time and to help one another predict what the results will be.

Record your moves here.



Creating a Rubik's® Cube Mosaic: Making a Multi-colored Cross

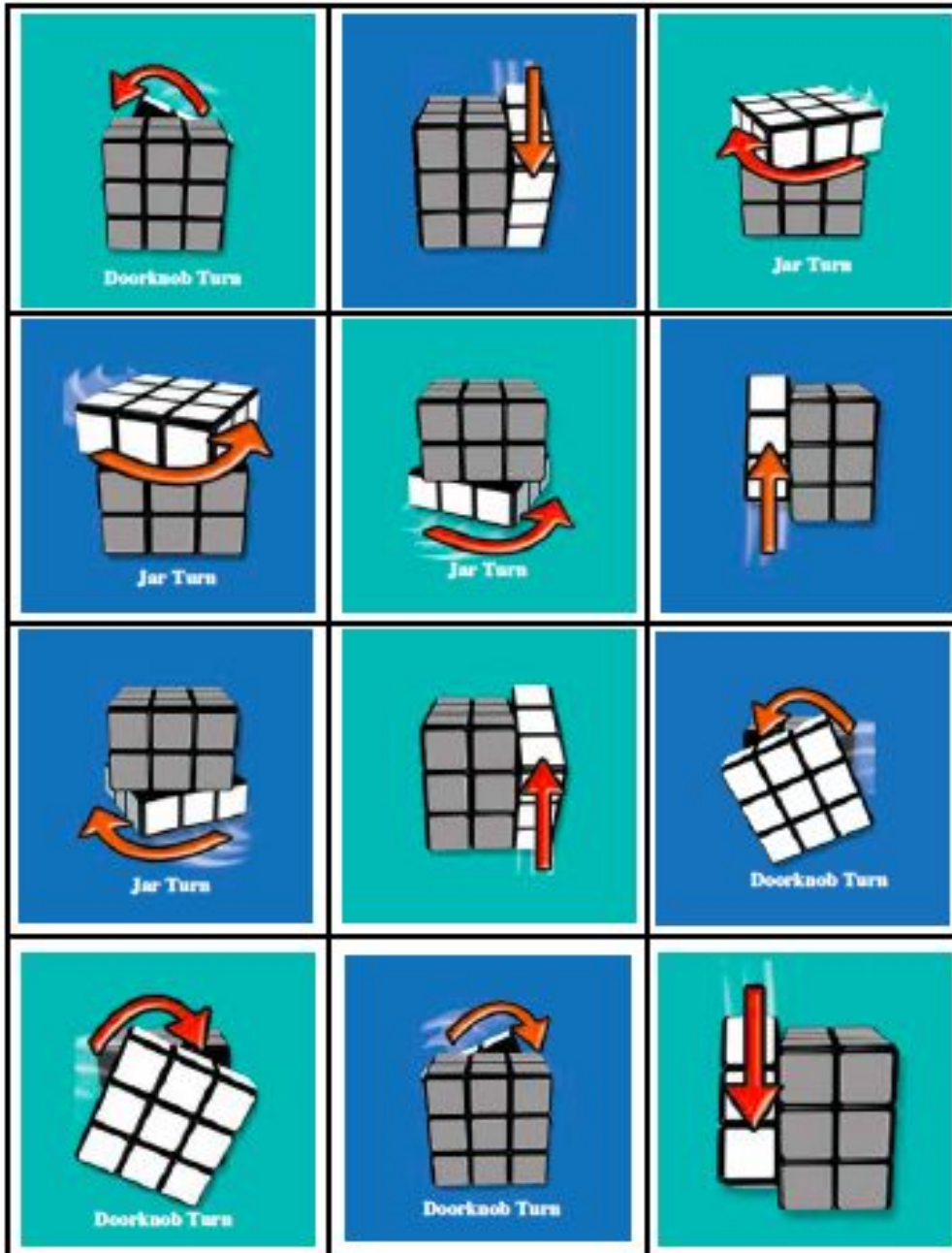
Review Lesson

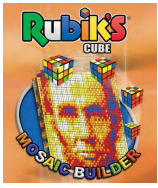
I CAN Do The Cube

Rubik's® Turn Cards

MEMORY GAME

- Cut out each playing card.
- Place them upside down.
- Take turns trying to match the image with the correct letter representation.





Creating a Rubik's® Cube Mosaic: Making a Multi-colored Cross

I CAN Do The Cube

Review Lesson

R

Ri

L

Li

B

Bi

D

Di

F

Fi

U

Ui