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.


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

In this lesson, students will learn how to solve the cross or + on the UP 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. This lesson may be suitable for older students with some modifications.

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
Materials:
- A Rubik’s Cube for each student
- A Rubik’s Cube Mat for each student
- Handout for each student, group, or learning station
- Rubik’s Cube Turns 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
- Small dot stickers that are easy to remove or dry erase markers

Background knowledge:
Students should be familiar with the vocabulary of the Rubik’s Cube (edge, corner, center pieces and UP, DOWN, FRONT, BACK, LEFT & RIGHT faces). They should understand that one turn of the Rubik’s Cube in any given direction is a $90^\circ$ turn.

Teacher Notes:
Encourage students to use:
- the Rubik’s Cube Mat to help orient the faces (UP, FRONT, RIGHT, …).
- the Rubik’s® Turn cards as they record their moves during the activity. This will make it easier to “undo” their steps at the end of the lesson.
- a small sticker (or a dot with a dry erase marker) on the tile that they are following.
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 Rubik’s Cube. Once you learn the pattern, you can make wonderful pieces of Rubik’s Cube 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 Rubik’s Cube.

You are going to change the top or UP face to make this pattern:

First, color the cross or + from the UP face of the Rubik’s Cube above on the grid.

- How should you hold the Rubik’s Cube? What color will be on the UP face? How do you know?

- Will any of the edge pieces be in the correct position? How do you know?
Teacher Notes: Encourage students to use the Rubik’s® Cube Mat for this activity.

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 Rubik’s Cube. Once you learn the pattern, you can make wonderful pieces of Rubik’s Cube 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 Rubik’s Cube.

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

First, color the cross or + from the UP face of the Rubik’s Cube above on the grid.

- How should you hold the Rubik’s Cube? What color will be on the UP face? How do you know? The UP face should be red because the middle tile is red. The middle tile 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.
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For now, we don’t care about the corner pieces. Two blue tiles need to be put on the UP face. There are many ways to do this. One way is to hold the Rubik’s Cube so that the blue face is the RIGHT face, like this:
The FRONT face will be yellow.

- Find the red/blue edge piece. On which face does the blue tile this piece wind up when you turn the RIGHT face toward you (R’ turn)?

- Turn the RIGHT face toward you again. Where is the blue tile 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?
Teacher Notes: Encourage students to use:

- the Rubik’s Cube Mat to help orient the faces (UP, FRONT, RIGHT, …).
- the Rubik’s® Turn cards as they record their moves during the activity. This will make it easier to “undo” their steps at the end of the lesson.
- a small sticker (or a dot with a dry erase marker) on the tile that they are following.

For now, we don’t care about the corner pieces. Two blue tiles need to be put on the UP face. There are many ways to do this. One way is to hold the Rubik’s Cube so that the blue face is the RIGHT face, like this: The FRONT face will be yellow.

- Find the red/blue edge piece. Where does the blue tile on this piece wind up when you turn the right side toward you (R’ turn)?

  FRONT BACK LEFT RIGHT UP DOWN

  The blue tile 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 tile on the red/blue edge piece now? RIGHT face but now in 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 face 360°.

While students can easily follow the arrows on the turn cards, 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. An apostrophe following the turn notation means inverted or inverse. R, a counter-clockwise turn, would be the inverse or opposite of R’, a clockwise turn.
● Follow the directions you wrote. Were you correct?
You may want to give students a set of Rubik’s Cube 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 talk 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 he’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 Rubik’s Cube so the UP 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 UP face one turn to the right (U turn), as if you are closing a jar. Where is the blue tile on the red/blue edge piece now?

FRONT BACK LEFT RIGHT UP DOWN

- Without turning the Rubik’s Cube yet, predict where the blue tile will be if you turn the UP face again one turn to the left.

- Now make that one turn. Were you correct?

- Turn the UP face twice to the left (U’ turn), as if you are opening a jar. Where is the blue tile now?

- Where will the red/blue edge be if you follow these directions?
- 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.

- 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?
Teacher Notes: Encourage students to use:

- the Rubik’s Cube Mat to help orient the faces (UP, FRONT, RIGHT, ...).
- the Rubik’s® Turn cards as they record their moves during the activity. This will make it easier to “undo” their steps at the end of the lesson.
- a small sticker (or a dot with a dry erase marker) on the tile that they are following.

Hold your solved Rubik’s Cube so the UP 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 Rubik’s Cube, as determined by the center tile. The red face is always opposite the orange face; blue, opposite green; yellow, opposite white. Because red is the UP face, the blue face is always adjacent to the yellow and white (left and right). Red and orange in this lesson are the UP and DOWN faces.

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

Front Back UP 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 tile in the left column or side of the right face.

- Without turning the Rubik’s Cube yet, predict where the blue tile will be if you turn the UP face again one turn to the left. Left face

- Now make that one turn.
  Were you correct?

- Turn the UP face twice to the left (U’ turn), like you are opening a jar. Where is the blue tile 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?

![Image of Rubik's Cube moves]

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. Although there may be many correct answers, the most efficient are to “undo” the previous moves by turning then.

![Image of Rubik's Cube moves]

Encourage students to use the Rubik’s Cube 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.
Hold your solved Rubik’s Cube so the UP 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 (F’ turn). Where is the blue tile on the red/blue edge piece?

  FRONT  BACK  LEFT  RIGHT  UP  DOWN

- Where is the blue tile on the yellow/blue edge?

  FRONT  BACK  LEFT  RIGHT  UP  DOWN

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

  FRONT  BACK  LEFT  RIGHT  UP  DOWN

Predict where the blue tile on the yellow/blue edge will be.

  FRONT  BACK  LEFT  RIGHT  UP  DOWN

- Now make that one turn. Were you correct?
- Turn the FRONT face twice to the right (F2 turn), as if you are opening a door. Where is the **blue tile** on the **yellow/blue edge** now?

  FRONT  BACK  LEFT  RIGHT  UP  DOWN

- Where will the **blue tile** on the **red/blue edge** be if you follow these directions?

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

- What turn should you make to put the **blue tile** on the **red/blue edge** on the left side of the UP face of the Rubik’s® Cube?
Teacher Notes: Encourage students to use:

- the Rubik’s Cube Mat to help orient the faces (UP, FRONT, RIGHT, ...).
- the Rubik’s® Turn cards as they record their moves during the activity. This will make it easier to “undo” their steps at the end of the lesson.
- a small sticker (or a dot with a dry erase marker) on the tile that they are following.

If this is NOT day 2 of the lesson, you may want to omit the next question.
Hold your solved Rubik’s Cube so the UP 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 tile on the red/blue edge piece?
  FRONT BACK LEFT RIGHT UP DOWN
  F’ here does not move the red/blue edge

- Where is the blue tile on the yellow/blue edge?
  FRONT BACK LEFT RIGHT UP DOWN

- Without turning the FRONT face again one turn to the left, predict where the blue tile on the red/blue edge will be.
  Predict where the blue tile 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 tile 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 tile on the yellow/blue edge now? Back in its original position as you are “undoing” the previous moves. The inverse of F’ is F.
● Where will the blue tile on the red/blue edge be if you follow these directions? UP face

![Image showing cube moves](image)

● What do you notice about the red/blue edge?
The blue tile is now on the UP face instead of the lateral (side) face. The red tile is now on the lateral face instead of on the UP face. The edge piece has "flipped."

● What turn should you make to put the blue tile on the red/blue edge on the left side of the UP face of the Rubik's® Cube?
Turn the UP face to the right (U') 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 cross design on the UP face of your Rubik's Cube? Record your turns here.

- Because we started with a solved Rubik's Cube, there is an easy way to put another blue tile in the cross. 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?

- What turn(s) should you make to “undo” your directions so the cross design goes back to looking like this?
**Teacher Notes:** Encourage students to use:
- the Rubik’s Cube Mat to help orient the faces (UP, FRONT, RIGHT, ...).
- the Rubik’s® Turn cards as they record their moves during the activity. This will make it easier to “undo” their steps at the end of the lesson.
- a small sticker (or a dot with a dry erase marker) on the tile that they are following.

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

- Because we started with a solved Rubik’s Cube, there is an easy way to put another blue tile in the cross design. Predict which turn you should make. Record your turn here. Turn left face away from you, \( L' \), or Back face to the left, \( B \).

- Follow your directions. Were you correct? Answers may vary.

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

- What turn should you make to “undo” your directions so the cross design goes back to looking like this? \( L \) or \( B' \)

*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 tile in the correct position. Start with a solved Rubik’s® Cube. Hold the Rubik’s Cube so the UP face is red and the FRONT face is yellow.

- Find the red/yellow edge. Turn the FRONT face one turn to the right, F, as if you were turning a doorknob. Where is the red tile on the red/yellow edge now?

  FRONT BACK LEFT RIGHT UP DOWN

- Predict where the red tile 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, F’2, as if you are turning a doorknob backwards. Where is the blue tile on the yellow/blue edge now?

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

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

● What turn should you make to put the **blue tile** on the yellow/blue edge on the UP face of the Rubik’s Cube?
Teacher Notes: Encourage students to use:

- the Rubik’s Cube Mat to help orient the faces (UP, FRONT, RIGHT, ...).
- the Rubik’s® Turn cards as they record their moves during the activity. This will make it easier to “undo” their steps at the end of the lesson.
- a small sticker (or a dot with a dry erase marker) on the tile that they are following.

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 Rubik's Cube so the UP 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 tile on the red/yellow edge now?
  
  FRONT BACK LEFT RIGHT UP DOWN

- Predict where the red tile 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 tile 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 tile on the yellow/blue edge be if you follow these directions. Left side of FRONT face

- Follow the directions above. Were you correct? Answers may vary.

- Where is the blue tile on the blue/red edge? On the right side of the UP face

- What turn should you make to put the blue tile on the yellow/blue edge on the UP face of the Rubik’s Cube? F’ Students might note that the cross pattern they have been making is now on the UP 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.
Color a new cross or + pattern on the UP 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.
Teacher Notes: Encourage students to use:
- the Rubik’s Cube Mat to help orient the faces (UP, FRONT, RIGHT, ...).
- the Rubik’s® Turn cards as they record their moves during the activity. This will make it easier to “undo” their steps at the end of the lesson.
- a small sticker (or a dot with a dry erase marker) on the tile that they are following.

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 Cube Turn cards to help them plan. Perhaps they will work in pairs. There should be variations of the sequence to position each edge piece. This sequence generally takes an edge piece on the UP layer and flips the piece so that the UP tile of the edge piece swaps position with the lateral tile. 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.
Rubik's® Cube Mat

- Place your Rubik's Cube (or Rubik's Mini) in the blue box. This will help you keep track of which face should be the FRONT as you solve.
- As much as possible, keep your Rubik's Cube on the mat as you follow the algorithms.

The Rubik's Cube mat is a tool to help solve the Rubik's Cube or Rubik's Mini. It should be used with the YOU CAN DO THE RUBIK'S CUBE or YOU CAN DO THE RUBIK'S MINI solution guides. The guides may be downloaded from the website below.
Make 2 copies of this page. The letter cards are the same for Rubik’s Cube turns and for Rubik’s Mini turns.

R R' L L'
F F' B B'
U U' D D'