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.

In this lesson, students will learn how to solve the corners of 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.

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
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 UP, DOWN, FRONT, BACK, LEFT & RIGHT faces) and how to solve the cross or +. They will come close to mastering how to solve one face of the Rubik’s Cube by the end of the lesson.

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.
Now that you can make the cross or +, it’s time to learn about the corner pieces. Start with a solved cube. Hold the Rubik’s Cube so that the RIGHT face is the blue. Will everyone have the same color on the FRONT face?

- Find the red/yellow/blue corner. Hold the Rubik’s Cube so the red/yellow/blue corner is the UP, RIGHT, FRONT corner. The RIGHT face of the Rubik’s Cube is blue.

- You have looked at what happens to the edge pieces when you turn the right side toward you (counterclockwise turn). This time you will look at what happens to the corner piece. Turn the right side once towards you \( (R') \). Where does the red/yellow/blue corner go?

- What color of the red/yellow/blue corner shows on the FRONT face?

- Turn the right side toward you again. Where is the blue tile on the red/yellow/blue corner now?

- Without turning, predict what turns you should make to move the red/yellow/blue corner back to the UP right of the FRONT 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?
Adding Multi-colored Corners to a Rubik’s® Cube
Teacher Notes

Now that you can make the cross or +, it’s time to learn about the corner pieces. Start with a solved cube. Hold the Rubik’s Cube so that the blue face is the RIGHT face. Will everyone have the same color on the FRONT face? Since the color of the UP face was not specified, some students will have yellow on the FRONT, some may have white.

- Find the red/yellow/blue corner. Hold the Rubik’s Cube so the red/yellow/blue corner is the UP, RIGHT, FRONT corner. The RIGHT face of the Rubik’s Cube is blue.

Now, everyone should have yellow as the FRONT face.

- You have looked at what happens to the edge pieces when you turn the right side toward you (counterclockwise turn). This time you will look at what happens to the corner piece. Turn the right side once towards you (R’). Where does the red/yellow/blue corner go? Lower right corner of the FRONT face.

What color of the red/yellow/blue corner shows on the FRONT face? Red. You may want to ask about the other 2 sides of the corner so that students notice that the blue tile remains on the blue face.

- Turn the right side toward you again. Where is the blue tile on the red/yellow/blue corner now? The blue tile remains on the blue face but now it is in the lower back corner. You may want to ask students where the red and yellow tiles are.

Without turning, predict what turns you should make to move the red/yellow/blue corner back to the UP right of the FRONT face. 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 review the inverted notation. (Imagine you are facing the Right side.)

- 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, one of the 2 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 in the You CAN Solve 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.

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Adding Multi-colored Corners to a Rubik’s® Cube

Hold your solved Rubik’s Cube so the UP face is red and the RIGHT face is blue.

- Find the yellow/blue/orange corner. Hold the Rubik’s Cube so the yellow/blue/orange corner is the lower right of the FRONT face and the RIGHT face of the Rubik’s Cube is blue.

Without turning the Rubik’s Cube yet, predict where the blue tile on the yellow/blue/orange corner will be if you turn the DOWN face again one turn to the left.

- Now make that one turn. Were you correct?

- Turn the DOWN face twice to the right (clockwise or D2), as if you are closing a jar. Where is the blue tile on the yellow/blue/orange corner now?

- Put the yellow/blue/orange corner back where it was when you started. What turn or turns did you make?

- Where will the yellow/blue/orange corner be if you follow these directions?

- What color of the yellow/blue/orange corner is on the FRONT face? How has the corner Rubik’s Cube changed?
● Where does the red/yellow/blue corner go?

● Looking at the red/yellow/blue corner, what color is the tile that shows on the FRONT face?

● Which of the other corner pieces moved?

● Where did they wind up? Label each corner with its colors. Color the tiles of the corners you can see.

● Describe to a partner how the colors of the edge pieces changed places. Why did the colors change places?
Adding Multi-colored Corners to a Rubik's® Cube

- Predict which turns should you make to put the **yellow/blue/orange** corner on the TOP layer of your Rubik's Cube. Record your turns here.

- Follow the directions you wrote. What color is the tile on the UP face?

- Record the steps you would use to return the Rubik's Cube to the solved state. Then follow the steps you wrote.
Adding Multi-colored Corners to a Rubik’s® Cube

Teacher Notes

Hold your solved Rubik’s Cube so the UP face is red and the RIGHT face is blue.

- Find the yellow/blue/orange corner. Hold the Rubik’s Cube so that corner is the lower right of the FRONT face and the RIGHT face of the Rubik’s® Cube is blue. The yellow/blue/orange corner will be on the lower right of the FRONT face. The UP face will be red.

Without turning the Rubik’s Cube yet, predict where the blue tile on the yellow/blue/orange corner will be if you turn the DOWN face again one turn to the left. The blue tile will now be on the left side of the FRONT face. Now make that one turn. Were you correct? Have students help one another to get the blue tile in the correct position.

- Turn the DOWN face twice to the right (clockwise or D2), as if you are closing a jar. Where is the blue tile on the yellow/blue/orange corner now? The blue tile will be on the BACK face, left side of the bottom layer if you were looking at the BACK face.
- Put the yellow/blue/orange corner back where it was when you started. What turn or turns did you make? Turn the Down face one turn to the left, D’.
- Where will the yellow/blue/orange corner be if you follow these directions? The lower right of the FRONT (see below)

- What color of the yellow/blue/orange corner is on the FRONT face? Blue.
- How has the corner Rubik’s Cube changed? Students should notice that it is the lower right corner instead of the lower left corner. The yellow tile is on the DOWN face instead of the lateral face. The orange tile is on the lateral face instead of the DOWN face. The corner has “turned” or “flipped.”

- Where does the red/yellow/blue corner go? It is on the lower left FRONT face.
- What color is the tile that shows on the FRONT face? Blue. Perhaps students will notice that this corner is flipped as well.

- Which of the other corner pieces moved? The two corners that did not move are the red/green/white corner and the red/green/yellow corner because they are both on the left side of the UP face. Have the students describe how the other corners moved. The orange/green/yellow corner and the orange/green/white did not flip because they only rotated on the bottom layer (D').

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Adding Multi-colored Corners
to a Rubik’s® Cube

Teacher Notes

- Where did they wind up? Label each corner with its colors. Color the tiles of the corners you can see. The center tiles have been colored to help orient the Rubik's Cube. You may want students to do this as well. The visible edge pieces are ignored. You may want students to X them out.

Image found at:
http://www.clker.com/clipart-rubiks-cube-white.html

- Describe to a partner how the colors of the edge pieces changed places. Why did the colors change places? You may want to have students color the edge pieces so that they can see the change. (see below) Have students pair up so that one student has a solved Rubik’s Cube and the other has the Rubik’s Cube after the two turns have been made so that they can more easily compare how the edges have moved. In general, one move changes the location; two moves, in different directions, flips the edge.
Adding Multi-colored Corners to a Rubik’s® Cube

Teacher Notes

● Predict which turns should you make to put the yellow/blue/orange corner on the top layer of your Rubik’s Cube. Record your turns here.

● Follow the directions you wrote. What color is the tile on the UP face? Blue.

● Record the steps you use to return the Rubik’s Cube to the solved state.

Undoing the turns that were made
Adding Multi-colored Corners to a Rubik’s® Cube

Hold your solved Rubik’s Cube so the UP face is red and the RIGHT face is blue.

- Make these turns. Predict where the red/yellow/blue corner will be when you are done.

- Color the corners of the Rubik’s Cube below. Write the colors of the tiles you can’t see on the lines.
● Find the **green/yellow/orange** corner piece. Find the **green/yellow/orange** corner piece. What **corner** is directly above it?

● Record the turns you will need to swap those corner pieces.

● Where is the **yellow tile** of the **green/yellow/orange** corner piece now?
Hold your solved Rubik’s Cube so the UP face is red and the RIGHT face is blue.

- Make these turns. Predict where the red/yellow/blue corner will be when you are done.
- It will be in its original position. However, the yellow tile will be on the UP face; blue, on the FRONT; red, on the RIGHT.

- Color the corners of the new Rubik’s Cube pattern below. Write the colors of the tiles you can’t see on the lines.

- Find the green/yellow/orange corner piece. What corner is directly above it? yellow/blue/red

- Record the turns you will need to swap those corner pieces.

- Where is the yellow tile of the green/yellow/orange corner piece now? On the UP face

Have students “undo” all the directions so that the Rubik’s Cube is returned to a solved state.
Adding Multi-colored Corners to a Rubik's® Cube

- Start with a solved Rubik's Cube. You are going to put this pattern on the UP face of the Rubik's Cube.

What color should the UP face be?

What color should the RIGHT face be?

What turns will you need to make to create this design on the UP face of your Rubik's Cube? Record your turns here.
Adding Multi-colored Corners to a Rubik’s® Cube

Teacher Notes

- Start with a solved Rubik’s Cube. You are going to put this pattern on the UP face of the Rubik’s Cube.

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[Image]
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What color should the UP face be?
Since the center tile is green, the UP face must be green.

What color should the RIGHT face be?
Since the right edge piece is white, hold the Rubik’s Cube so the white face is white.

What turns will you need to make to create this design on the UP face of your Rubik’s Cube?
Record your turns here.
Always begin with the edge pieces. Follow the steps to flip the edge piece.

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[Images]
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The lower right corner on the UP face is now blue so you have created the desired pattern.

**Have students “undo” their directions so that the Rubik’s Cube is returned to a solved state.**
Start with a solved Rubik's Cube. You are going to put this pattern on the UP face of the Rubik's Cube.

What color should the UP face be?

What color should the RIGHT face be?

What turns will you need to make to create this design on the UP face of your Rubik's Cube? Record your turns here.
Adding Multi-colored Corners to a Rubik's® Cube

Teacher Notes

- Start with a solved Rubik's Cube. You are going to put this pattern on the UP face of the Rubik's Cube.

What color should the UP face be? **Blue** because the center tile is blue.

What color should the RIGHT face be? Since we start with the edge pieces, the possibilities for the right side are either green or red, the two colors which are not already edge pieces. **Green** is the DOWN face of the Rubik's Cube when blue is the UP face. So, the RIGHT face must be red.

What turns will you need to make to create this design on the UP face of your Rubik's Cube? Record your turns here. **Here is one possibility:**

- **B2** or **B'** will move the green/yellow edge to the UP face.

- **R', U, F, U'** will flip the blue/red edge so that the red tile is on the UP face.

Now, you need to flip the corners.
Turn the DOWN face 2 turns counterclockwise to position the yellow/red/blue corner under the blue/yellow/orange corner. Notice that the red tile will be on the RIGHT face of the Rubik's Cube.

Now that the correct corner is in position, follow the steps for flipping the corners.
Keeping the UP face blue, rotate the entire Rubik’s Cube so that the RIGHT face is orange (center tile). Notice that the yellow/orange/green corner is below the green/yellow/red corner. The orange tile which you want on the UP face is currently on the RIGHT face. Now that the correct corner is in position, follow the steps for flipping the corners.

Have students “undo” their directions so that the Rubik’s Cube is returned to a solved state.
Rubik's® Cube Turn Cards

- Bottle turn
- Bottle turn
- Bottle turn
- Bottle turn

- Doorknob turn
- Doorknob turn
- Doorknob turn
- Doorknob turn

- Ferris wheel turn
- Ferris wheel turn
- Ferris wheel turn
- Ferris wheel turn
Make 2 copies of this page. The letter cards are the same for Rubik’s Cube turns and for Rubik’s Mini turns.