Math in Motion

Grades 3-5
A Tessellation Quilt

Summary: Students will extend the "hands-on" tessellation activity that was introduced in the IDEA Place. Students will create an original tessellation design and display it in a class tessellation quilt.

NCTM Standards: Standard 9—Geometry and spatial sense

National Science Standards: Unifying Concepts and Processes
Evidence, models, and explanation

Objectives:
To define basic geometric terms.
To explore shapes that tile the plane and the moves used to make tilings.
To identify the transformations (moves) used in creating a tessellation.
To begin to see a relationship between the shape of a tile and its tessellation.
To make connections between math and art.

Materials:
a variety of shapes cut from cardstock or posterboard
8" x 8" squares of white paper (one per student)
3" squares of posterboard
colors or markers

Procedures:
1. Introduce or review geometric terms to help students understand the process of tessellation. (See attached glossary.)
2. Let students explore using geometric shapes of their own choice including pentagons, different types of quadrilaterals, and irregular triangles to discover which shapes will tessellate and which will not. Students can trace the shape on a sheet of paper to determine if it will tessellate or not. Create a class chart of shapes that will tessellate/ won't tessellate. Students can place examples of their work on the appropriate place on the chart.
3. Share M. C. Escher art books with students. Ask them to look for basic geometric shapes as well as any irregular features that Escher used in his tessellations.
4. Translations or slides: Students should begin with a three inch square cut out of posterboard. Color one side of the square to prevent students from accidentally turning over the pieces that are cut.

   a. Cut into one corner of the square and end your cut at an adjacent corner.
   b. Slide the cut piece to the opposite side, line it up with the straight edge and tape.
c. Repeat this process with the other pair of sides.
d. Trace the tessellated shape in the center of a piece of paper. Slide the
shape up, down, left, or right and trace. Continue to trace the shape until the
page is covered. Monitor students as they work to see that they do not flip
the piece over or rotate it as they do repeated tracings.
e. After students have had the opportunity to explore the slide technique,
let them add detail and color to a favorite tessellation.
f. Completed tessellations are displayed in the tessellation quilt. (See
attached sheet with directions for making the quilt.)

**Background Information:** A tessellation is a repeated pattern that covers a plane with
no overlapping or holes.

**Assessment:** Teacher observation of students. The teacher will also interact with
students as they work and encourage them to verbalize their thinking.

**Resources:** Cittadino, Mary J. Z & Giganti, Paul; March 1990, “The Art of Tessellation,” *Arithmetic Teacher,* pp. 6-16.

Submitted by Marty Kilgore
Glossary of Tessellating Terms

**congruent:** Same size and shape

**polygon:** Closed figures formed by straight line segments. 
  *poly* means many; *gon* means angle

**regular polygon:** It has all sides congruent and all angles are congruent.

**quadrilateral:** Any polygon with four sides.

**square:** Two pairs of parallel sides, all sides congruent, four right angles.

**rectangle:** Two pairs of parallel sides, opposite sides congruent, four right angles.

**rhombus:** Two pairs of parallel sides, all sides congruent.

**parallelogram:** Two pairs of parallel sides.

**kite:** Two distinct pairs of adjacent sides congruent (note that flipping or reflecting a triangle will result in a kite.)

**regular tessellation:** Covers the plane with repetition of one particular regular polygon

**side:** A straight line segment of a polygon, for example, a dodecagon is a polygon with twelve sides.

**similar:** Same shape but not necessarily the same size.

**transformation:** Correspondence or matching between points of the plane, for instance, by rotation or reflection.

**trapezoid:** One of and only one pair of parallel sides

**vertex:** Point where two sides meet
Tessellation Quilt Instructions

Materials:

☐ 8"x8" squares of white paper (one per student)
☐ colors or markers (bright colors are best)
☐ quart size Ziploc bags (25 bags will make a quilt that is 5x5)
   Additional bags will be needed to make larger quilts. You should make
   a quilt that has enough bags so that each student can put his work in
   it.
☐ 1 roll of colored masking tape.

Procedures:

Students will create a class tessellation quilt. Each student will create a
   tessellation pattern for the quilt.

1. Constructing the quilt - Place a row of the desired number of Ziploc
   bags on a table top. The printed side should be face down. The bags
   should be touching on the sides. Tape across the top front of the
   bags and along the bottom edge of the bags.

   Repeat this step for the number of bags desired. After each row has
   been taped, rows will be taped together horizontally. Be sure the
   bottom of the first row is placed on top of the second row before
   taping. Tape the two rows together.

   Continue taping the rows together until the quilt is complete. Next use
   the masking tape to make vertical seams taping from top to bottom of
   the quilt.
2. Cut completed tessellations to 6"x8½" size and insert into bags. Hang completed quilt for display.
Building Power

Summary: Students will extend the Building Adventures with Duplo Blocks exhibit in the IDEA Place. In this activity your students will discover how much weight an eggshell can support as a result of its geometric shape. Buildings are designed in various shapes to provide the strongest, longest lasting structure. A shape that supports a lot of weight is the dome. Why? The weight in a dome is dispersed along the curved walls to the wide base. There is no single point on the dome that supports the whole weight of the object on top of it. This is the reason that domes are used in big buildings that can’t have pillar supports, such as the Superdome and other sports arenas.

NCTM Standards: Standard 9—Geometry and Spatial Sense

National Science Standards: Physical Science
Properties of objects and materials; motions and forces
Scientific Inquiry—Abilities necessary to do scientific inquiry

Objective:
To demonstrate that the distribution of forces on an object tends to increase an object’s strength.

Materials:
4 raw eggs
1 pair of scissors (small ones work best)
masking tape
a collection of books that are all about the same size
a scale that measures a large # of Kg

Procedure:
1. Gently break open the eggshell at the small end of each egg by tapping it on a table or counter.
2. Carefully peel away a piece of the eggshell and scoop or pour out the egg inside.
3. Place a piece of masking tape around the middle of the shell to prevent the eggshell from breaking when you cut it.
4. Carefully cut around the shell of the egg, through the tape, so that you have 4 eggshell halves with even bottoms.
5. Put the eggshells on a table or on the floor with the open end down. Place them in a rectangle that’s slightly smaller than one of the books.
7. Continue adding books until the eggshells give way.
8. For Older Students: weigh the books to determine the number of Kg your structure would hold. Which eggshell broke first? Can you predict the reason(s)?
9. Extensions:
   Have students determine how much weight a single eggshell can support. Will one eggshell support the weight of a student?
   Have students rearrange the eggshells in different geometric forms such as a triangle, a square, etc. Which structure will hold the greatest amount of weight?
   Have students interview an engineer about his/her career.
   Soak the eggshell in vinegar overnight and reapply the force of the books, adding them one at a time. (this extension demonstrates the erosion of the strength of a building material made of minerals after a long period of exposure to acid rain).

**Assessment:** Informal assessment through questioning:
1. Predict the number of books your structure will hold?
2. How would it change the results if you had moved the eggshells in a square closer together?
3. What other factors could affect the strength of the structure?

Possible Problems:
This activity has potential to create a mess. Provide clear instructions to students about the proper procedure for waste disposal.

Make a Line

Summary: Students will extend the Coordinate Graphing activity in the Math in Motion exhibit in the IDEA Place.

NCTM Standards: Standard 10--Measurement

National Science Standards: Physical Science
Position and motion of objects

Objectives:
To locate points on a coordinate grid.
To determine if three points are in a line.

Materials: For each pair of students--
a coordinate grid labeled 0-6
a pair of dice (1 red, 1 green)
two crayons (different colors)
fine line black marker
ruler

Procedures:
1. Explain that the red die tells the number of moves to the right and the green die tells the number to move up.
2. Two children work together. The first child throws the dice and plots the point with his crayon. The other child does the same, marking his point with his choice of crayon.
3. The first child to locate three points on the same line and connect the points with the marker using the ruler is the winner!

Assessment: Teacher observation of students. Coordinate grids made by students.


Submitted by Carol B. Massey
Tangrams

Summary: Students will extend the hands-on tangrams activity in the Math in Motion exhibit by developing an understanding of spatial relationships in this activity.

NCTM Standards: Standard 9—Geometry and Spatial Sense

National Science Standards: Unifying Concepts and Processes
Evidence, models, and explanations

Objectives:
To name different geometric shapes.
To appreciate cooperative learning.
To practice spatial visualization.

Materials:
tangram puzzle pieces (included)
tangram shape sheet (included)

Procedures:
1. Help children cut out the seven tangram pieces very carefully.
2. Work together using all seven of the tangram pieces to cover the bird shape.
3. Make more puzzles by making interesting arrangements with all seven tangram pieces. Trace carefully around the outside of the design to make the outline of the new puzzle. Remove the pieces and give the puzzle to a friend to try.
4. Use all seven tangrams pieces to make your first initial. Trace its outline and cut it out of bright paper. Now make your last initial.

Background Information: Tangrams are ancient Chinese puzzles that consist of seven pieces cut from a square. They can be rearranged to make different figures.

Assessment: Student performance of activity being completed.

MAKE YOUR OWN TANGRAMS

Cut out the pieces of one square to make a set of tangrams. Use the pieces to make tangram pictures or shapes. Store the tangram pieces in an envelope when you are finished.

Adapted from a publication in Family Math.
Tangram Bird
# TANGRAM SHAPES

Make a record of shapes that can be made with different numbers of tangram pieces. Draw your solution on the chart.

<table>
<thead>
<tr>
<th>Number of pieces used</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Shape Made</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Square</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Triangle</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rectangle</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trapezoid</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parallelogram</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rhombus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pentagon</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Adapted from a Family Math publication.
Tessellating Polygons

Summary: As a follow up activity to the tessellation exhibit in the IDEA Place, the students will learn how to find the number of degrees in the interior angle of a polygon and use this information to explore which polygons tessellate and why.

NCTM Standards: Standard 9—Geometry and Spatial sense

National Science Standards: Unifying Concepts and Processes
Evidence, models, and explanation

Objectives:
To find the measure of the interior angle of a regular polygon.
To discover the geometrical reasons why some shapes tessellate and others do not.

Materials: For each student—
polygon sheet
scissors
pencil
angle-measuring sheet
data chart

Procedures:
1. Cut out the polygons from the sheets provided.
2. Count and record the number of sides on each polygon.
3. Starting from one corner, draw as many triangles as you can inside of each polygon. Record this number in the data table. For example in a pentagon, three triangles can be drawn.
4. Fill out the rest of the data table to find the measurement of the interior angles of each of the polygons.
5. Try to tessellate each of the polygons. Which ones tessellate and which ones do not?
6. Put one polygon on the circle with one of its corners touching the center. Put another of the same kind of polygon right beside the first, with one of its points touching the center also. Repeat this until you have tiled all the way around the center of the circle. Do this with each polygon separately.
7. After completing your data tables, look at the information in them and answer the question, “How can I tell if a regular polygon will tile?”
**Background Information:** A tessellation is a repeated pattern that covers a plane with no overlapping or holes. Shapes with an interior angle that is a factor of 360 degrees, such as equilateral triangles, squares, and hexagons, will tessellate.

**Assessment:** Give the students pictures of regular polygons. See if they can repeat the steps in the activity and tell you whether the polygons will tessellate or not.


Submitted by Erika Stewart
Tessellating Polygons
Student Procedure Sheet

Procedure:
1. Cut out the polygons from the provided sheets.
2. Count and record the number of sides on each polygon.
3. Starting from the corner marked by an asterisk, draw as many triangles as you can inside of each polygon. Record this number in the data table. For example, in a pentagon, three triangles can be drawn.

![Pentagon with triangles drawn]

4. Fill out the rest of the data table to find the measurement of the interior angles of each of the polygons. You will multiply the number of triangles you can draw inside the polygon by 180° and then divide the resulting number by the number of sides in the polygon to get the number of degrees inside each angle.
5. Try to tessellate each of the polygons. Which ones tessellate and which ones do not?
6. Put one polygon on the circle with one of its points touching the center. Put another of the same kind of polygon right beside the first, with one of its points touching the center also. Repeat this until you have tiled all the way around the center of the circle. Do this with each polygon separately.
7. After completing your data tables, look at the information in them and answer the question, "How can I tell if a regular polygon will tile?"
Put one polygon on the circle with one of its points touching the center. Put another of the same kind of polygon right beside the first, with one of its points touching the center also. Repeat this until you have tiled all the way around the center of the circle.
### Tesselating Polygons

**Student Data Sheet**

<table>
<thead>
<tr>
<th>Regular Polygon</th>
<th>Number of Triangles $\times$</th>
<th>$180^\circ$ $\div$ Number of Sides $=$</th>
<th>Degrees in each inside angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equilateral Triangle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Square</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pentagon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hexagon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heptagon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Octagon</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Tesseling Polygons  
Student Data Sheet

Names ____________________________  

Which polygons will tessellate?  

Which polygons can tile around the center of the circle without overlap?  

How many degrees are there around the center of a circle? _____  

Divide the number of degrees around the center of a circle by the number of degrees in the interior angle of the polygon.

<table>
<thead>
<tr>
<th>Polygon</th>
<th>Degrees in a circle</th>
<th>Degrees in an interior angle</th>
<th>Quotient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triangle</td>
<td>____</td>
<td>____</td>
<td>____</td>
</tr>
<tr>
<td>Square</td>
<td>____</td>
<td>____</td>
<td>____</td>
</tr>
<tr>
<td>Pentagon</td>
<td>____</td>
<td>____</td>
<td>____</td>
</tr>
<tr>
<td>Hexagon</td>
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<td>____</td>
<td>____</td>
</tr>
<tr>
<td>Heptagon</td>
<td>____</td>
<td>____</td>
<td>____</td>
</tr>
<tr>
<td>Octagon</td>
<td>____</td>
<td>____</td>
<td>____</td>
</tr>
</tbody>
</table>

How can you tell which polygons will tile? ___________________________________
Equilateral Triangles

Squares
Heptagons