☆Star Search☆: Looking for the next M.C. Escher

Grade level: Grade 7 Mathematics

Overall Expectations:

- Describe location in the four quadrants of a coordinate system, dilate two-dimensional shapes, and apply transformations to create and analyse designs.

Specific Expectations:

- Plot points using all four quadrants of the Cartesian coordinate plane;
- Identify, perform, and describe dilatations (i.e., enlargements and reductions), through investigation using a variety of tools (e.g., dynamic geometry software, geoboard, pattern blocks, grid paper);
- Create and analyse designs involving translations, reflections, dilatations, and/or simple rotations of two-dimensional shapes, using a variety of tools (e.g., concrete materials, Mira, drawings, dynamic geometry software) and strategies (e.g., paper folding) (Sample problem: Identify transformations that may be observed in architecture or in artwork [e.g., in the art of M.C. Escher].);
- Determine, through investigation using a variety of tools (e.g., pattern blocks, Polydrons, grid paper, tiling software, dynamic geometry software, concrete materials), polygons or combinations of polygons that tile a plane, and describe the transformation(s) involved.

Big Ideas:

- A coordinate grid system can be used to describe an object's location on a plane/graph using the x /y axes
- Transformations describe the movement of a shape
- There are 3 types of transformations - rotations, translations, and reflections
- Rotations are described using angles, measured in degrees
- Shapes can have various points of rotation
- Translations are described using the grid units on a coordinate system (i.e. 2 units/spaces left, 3 units/spaces up)
- Reflections are described over the x axis or y axis
- Dilations are when the properties of the shape stay the same, but the object becomes bigger or smaller
- Tiling a plane requires that there is no free space between various shapes

Essential Questions:

- When transforming shapes, do the properties of a this change?
- What is the difference between transformations and dilations?
- What kinds of shapes can tile a plane?
- What properties do various shapes have to have common in order to tile a plane?
- What is rotational symmetry?
- Do all shapes have rotational symmetry?
- What are examples of shapes in nature that have natural rotational symmetry?
- Where can we find examples of tessellating patterns in nature and the world around us?

Unit Overview:

Throughout this geometry unit, students have learned about various transformations (reflections, translations, and rotations) and tessellations of shapes. This is the second portion of the geometry unit, the first focusing on classifications of angles and polygons, and was assessed separately. Students have used and expanded their knowledge from the first portion of geometry to further their understanding for this portion. In this unit, students have worked with various tools to explore transformations, such as geoboards, manipulatives, tracing paper, and online tools. Additionally, they have practiced tessellations on a 2D coordinate grid, using a variety of polygons. We also turned out classroom into a coordinate grid to help students visualize a Cartesian coordinate plane and practice transformations in a more visual way.

In this unit, we have also looked at designs by artists (such as M.C. Escher) that created amazing pieces of art using transformations and tessellations. In the picture below (called Lizard, from November 1942), Escher used a hexagon as the initial shape, and then reshaped it into a lizard.

Based on the principles of STEAM (Science, Technology, Engineering, Art and Math), this culminating assignment will assess transformations, transformations, and the Cartesian coordinate system. The students will be using 3D printing technology to create their own tessellating shapes. Students are allowed to design their shape in any way they want, but some may be creating M.C Escher type puzzles that highlight tessellating shapes found in nature. Students are not restricted to creating shapes that represent animals (similar to Escher's work), but they will be using his methodology of starting from a polygon, and then manipulating the angles and sides to create a shape of their choosing. For technology and engineering, they will be using these skills to perform the 3D printing. As well, the piece they create will reflect their artistic choices (including colour options). They are also given an additional optional component, where they may paint one side of their tessellating puzzle in any way of their choosing. Finally, the math and geometry skills they have learned throughout this unit will guide them in creating the shapes, transforming it across a Cartesian coordinate plane, and ensuring that their tessellating shapes tile a plane continuously and consistently.

Assignment Overview:

For this assignment, you will become our class' version of M.C. Escher! You will be using computer software and 3D printing technology to create your own 'Escher-type' puzzle, of a shape of your choice, that you will design. You will be using your knowledge of transformations and tessellations to create this pattern that will tile a plane. You will also be submitting a 2D version of your creation on a coordinate plane, with at least 5 shapes tiling the plane, with appropriate transformations and coordinates listed.

Your task:

You will be creating a tessellating shape by hand or with a computer program (Tesselmaniac). **Be creative!**

Before you start the 3D printer process, I would like to see your shape on a coordinate grid, with 5 transformations (at least). Your shape should begin to tile the plane, and you should list the transformations of each of the new locations of your shape **(with coordinates)**. If you used Tesselmaniac, you can print your shape in order to trace it. Show me your design and your 2D version of the tiled plane (with transformations).

Once this is teacher approved, you will be prepping this shape for the 3D printer!

If you drew the shape by hand:
- Input your shape into a program like Inkscape or Adobe Illustrator (we will go over how to use these in class).
- You may have to use a bezier curve tools (or something similar) to isolate your shape.
- Your goal is to export an SVG file that can be 3D printed.

If you used Tesselmaniac:
- Export your shape as an SVG file.

You will use a 3D printing program (such as Cura) to prep your design for 3D printing. You can choose to use different colours to create a more interesting pattern, but the completed puzzle should be fairly consistent looking. The folks in the Makerspace will help our class with the 3D printing.

When your design is finished, you will switch with a partner and they will try to solve your tessellating puzzle pattern!

As an additional component, you can also paint one side of your puzzle in any picture of your choosing. This may make the puzzle harder to solve though!

Sample projects:

http://www.thingiverse.com/thing:1318696
http://www.thingiverse.com/thing:1470332


Rubric for M.C. Escher Tessellation Project

	Level 1	Level 2	Level 3	Level 4
Transformations (for 2D tessellations on coordinate graph)	Student demonstrates **limited** ability to identify and represent various transformations	Student demonstrates **some** ability to identify and represent various transformations	Student demonstrates a **good** ability to identify and represent various transformations	Student demonstrates **thorough** ability to identify and represent various transformations
Using the coordinate system (for 2D tessellations on coordinate graph)	Student demonstrates **limited** ability to describe the location of transformed shapes with the coordinate system	Student demonstrates **some** ability to describe the location of transformed shapes with the coordinate system	Student demonstrates a **good** ability to describe the location of transformed shapes with the coordinate system	Student demonstrates **thorough** ability to describe the location of transformed shapes with the coordinate system
Tiling a plane (the final 3D printed tessellated puzzle)	Student **has difficulty** creating a design with their shape that will tile a plane. This design has **limited** consistency in colours, shape heights and/or patterns.	Student is **somewhat able to** create a design with their shape that will tile a plane. This design has **some** consistency in colours, shape heights and/or patterns.	Student is **able to** create a design with their shape that will tile a plane. This design has **good** consistency in colours, shape heights and/or patterns.	Student **excels** at creating a design with their shape that will tile a plane. This design has **thorough** consistency in colours, shape heights and/or patterns.

Students should submit:

- Final version of their 2D coordinate graph, with at least 5 transformations listed and the appropriate coordinates.
  If there are mistakes on the initial submission, correct these for the final submission.
- Their 3D printed tessellation pieces.