Symmetry and Congruency in the World of Art:
Through the eyes of a 2nd grader

Lindsay Hannum

School and Classroom Background

Davidson Elementary School is a suburban elementary school serving students kindergarten through 5th grade. The school is located in the heart of Davidson, North Carolina, twenty minutes north of Charlotte. The school is within walking distance to Davidson College and shares many partnerships with students as volunteers in classrooms. Davidson Elementary is part of the Charlotte Mecklenburg School district (CMS), which is the twenty-second largest district in the nation. Davidson Elementary has a student body made up of roughly 860 students. The majority of the students are Caucasian making up 85.7% of the population. 5.5% are African American, 1.7% are Asian and 3.1% percent are Hispanic. The school has a program for English as a Second Language students, a Talent Development program as well as a program for Exceptional Children (students with disabilities). 24.9% of our students are gifted and benefit from the TD program. 12.0% of the students are children with disabilities and receive services from the EC department. Davidson Elementary has a fairly affluent student body with only 7.8% of the student body qualifying as economically disadvantaged and receiving free or reduced lunch. The school has been an integral part of the community for the past thirteen years and has made Adequate Yearly Growth for several years as well as was been awarded the title of a Blue Ribbon School for the 2004-2005 school year.

This unit is written and appropriate for second grade students. I teach 2nd grade at Davidson Elementary with 23 students in my class at varying levels. Most of my students are performing at or above grade level. Seven of my students have been identified as gifted and are able to work with concepts beyond the 2nd grade objectives. Only four students (two of which are identified as English as a Second Language learners) are not performing at grade level and require one-on-one assistance to be able to complete certain tasks. With the varying levels in my classroom, this unit includes in depth information on symmetry and provides more detail than the district requires in order to reach the high performing students. However, it also still covers the required information for those at or below grade level. There are several activities in this unit that will be differentiated to meet the varying levels of students.

The PTO at Davidson is a very generous one, and has purchased many interactive white boards for our school. I am fortunate to have one in my classroom therefore; many of the activities and visual aids in this unit will require use the interactive whiteboard.

The visual aids can easily be transferred to overheads to use with a projector or viewed by a computer if you are unable to access an interactive whiteboard.

I teach Math using the CMS adopted curriculum program *Math Investigations* along with the North Carolina Standard Course of Study (NCSCOS). Through my teaching of math, I try to relate the concepts to "real life" in hopes of making things relevant to my students' own lives. This unit will be in addition to what I will already be teaching regarding symmetry and congruency through *Math Investigations*.

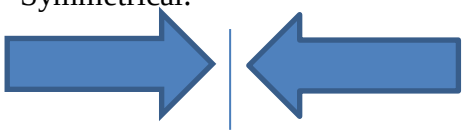
Unit Objective

Second graders are expected to identify and make symmetric and congruent figures; therefore studying artistic representations of those concepts is a way for them to make real life connections to mathematics and geometry. This unit will focus on symmetry and congruency through artwork that shows those characteristics. This unit will span over eight or nine days consisting of 45-60 minute sessions. It will cover identifying and creating reflection symmetry, rotational symmetry, point symmetry and congruent figures. Students will learn how to identify a symmetrical figure by finding lines of symmetry, order of rotation, and the point of origin as well as distinguish congruent figures by determining whether they are the same size and shape.

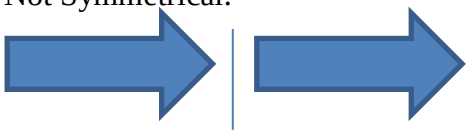
Mathematical Background Information

The most common form of symmetry and the easiest for students to identify is reflection symmetry, often called line or mirror symmetry. By definition a shape has reflection symmetry if there is a line through which the shape can be reflected over to create a mirror image. This can easily be confusing for 2nd graders as they believe shapes are symmetrical when they "identical" on both sides of a line. For an example, if you had a piece of paper with an arrow on one side, for it to be truly symmetrical, the arrow on the other side of the line of symmetry would have to flipped over, as in the illustration below.

Symmetrical:



Not Symmetrical:



Reflection symmetry can be determined by finding the shape's line of symmetry. When finding the line of symmetry, the line does not have to go left to right or up to down, it can go in any direction as long as the two images are reflections of each other.

Examples of reflection symmetry can be seen in basic shapes, but also in faces, insects such as the butterfly and in pieces of artwork as this unit will show. Reflection symmetry can also be seen when an image is reflected onto the surface of water. However, that is not perfect reflection symmetry because the water distorts the image from the original shape, as shown in the image below.

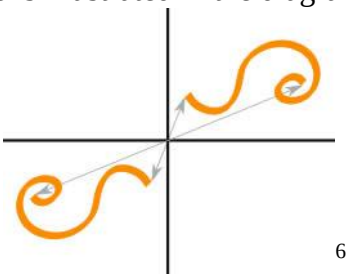
 [1]

Rotational symmetry by definition is when a shape or image remains the same after being rotated. The number of positions that the shape or image can be rotated to, without changing the way it originally looked determines its order of rotational symmetry. The number of sides a polygon has is related to its order. A square has rotational symmetry of order 4, a rectangle has rotational symmetry of order 2 and an equilateral triangle has rotational symmetry of order 3. A circle design would have in infinite order of rotational symmetry.

An artistic example of rotational symmetry and often reflection symmetry as well is what you see in the Mandala drawings most commonly used among Hindus and Buddhists. "A mandala is an imaginary palace that is contemplated during meditation. Each object in the palace has significance, representing some aspect of wisdom or reminding the meditator of some guiding principle. Tradition dictates the shapes, sizes and colors of these objects. There are many different mandalas, each with different lessons to teach. Most mandalas contain a host of deities as well as inanimate objects."[2] "Mandala is Sanskrit for circle, and the diagram is an intricate network of intertwining circles representing a many-layered universe." [3]Many different types and styles of Mandalas can be found on the web and in books. Below are two examples that easily display rotational symmetry as well as reflection symmetry, and will help 2nd graders identify both types of symmetry.


 [4]

The least common form of symmetry is point symmetry, which is closely related to rotational symmetry. "Point symmetry is sometimes called origin symmetry, because the "origin" is the central point about which the shape is symmetrical. Point symmetry is when every part has a matching part that is the same distance from the central point, but in the opposite direction."[5] This is illustrated in the diagram below:



[6]

For every figure that has point symmetry it also has rotational symmetry. It should be noted that not every figure that has rotational symmetry has point symmetry. Point symmetry is determined if a figure can be turned on a point at 180 degrees and land on an image of itself. (This is also rotational symmetry order of 2). More simply put, the image will look the same upside down or from any two opposite directions. Some examples of point symmetry are found in the images on playing cards, snowflakes, basketballs and the letters X, H, I, S, N and Z. Many images can be found just by simply searching "symmetry examples" in any search engine.

Strategies

The first strategy in this unit will be to inform students that symmetry and congruency concepts can be found in art and in the real world. To do this, present a short video from www.linkslearning.com introducing symmetry on an interactive whiteboard.[7] This video is a short overview of reflection symmetry and congruency and how to identify shapes and objects that have those qualities. It uses many real world examples that are fitting for this unit as we will be looking at symmetry and congruency in art. By using the interactive whiteboard not only during the video, but throughout the unit you will be able to use the pen tool and write on the board and over the shapes and images. Using this feature will help in showing how to find a line of symmetry, order of rotational symmetry, point symmetry and will also help to display congruent figures to students. You could also show this video using a computer if you do not have access to an interactive whiteboard.

After showing the video, define each form of symmetry that the unit will cover. Use the site: http://www.mathsisfun.com/geometry/symmetry.html displayed on an interactive whiteboard to aide in the delivery of the terms reflection symmetry, rotation symmetry and point symmetry. If you do not have access to an interactive whiteboard, it would be helpful to create an overhead of the definitions to show while you are discussing the

different forms of symmetry. This strategy will give students a clear definition of each type and a proper foundation to be able to continue with the unit's activities.

The second strategy will be to gather some art examples from books, pictures from magazines, mathematical journals, as well as images of popular pieces from famous artists and architects found online that show the different types of symmetry and congruency. Some of the popular pieces worth presenting would be The Pyramid at the Louvre, La Géode at La Villette, Arche de la Défense, Mandalas, the Taj Mahal, the London Bridge, Big Ben, the Washington Monument and many more examples can easily be found. Use these examples look at how the pieces utilize and display the characteristics and different types of symmetry and congruency which will help students better identify "math" in art. This will also give students clear, real life examples of both symmetry and congruency by discussing how the symmetrical examples have a line of symmetry, rotational order, or a point of origin and the congruent figures are the same size and shape.

Activities

The activities in this unit will help students better understand symmetry and congruent figures by making connections to the outside world through artwork. The students will also apply what they have learned by creating their own pieces illustrating those concepts to show their full understanding of the information as a close to the unit.

Day 1:

The lesson's activities will be the viewing of the video that introduces reflection symmetry and congruency spoken of in the strategies section. As a class, students will participate in practice activities during and at the end of the video that asks them to identify if the images are symmetrical and to decide where the line of symmetry would be. Throughout the activities students will be discussing where the line of symmetry is and will identify congruent figures within an image. After the video and quiz on reflection symmetry, students will then have additional practice with determining how many lines of symmetry famous flags have by using the flag quiz on this site displayed on an interactive whiteboard: http://www.adrianbruce.com/Symmetry/flags/quiz.htm. You could also use photos of the same flags and have the students view them that way if you do not have access to an interactive whiteboard, or have students take the quiz individually on computers in your school computer lab.

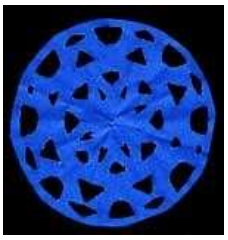
Students will then be able to further understand reflection symmetry by creating symmetrical designs using pattern blocks. If you have access to your school's computer lab, students could visit the national library of virtual manipulates site:

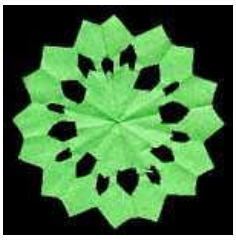
http://nlvm.usu.edu/en/nav/category_g_1_t_3.html to have students work with images of pattern blocks that will create reflection symmetry immediately after they click on particular shape. The program allows students to build symmetrical designs, move the line of symmetry and explore how reflection symmetry works. If you cannot get access to your school's computer lab, you can have students make their designs using actual pattern blocks instead.

Day 2:

After the introduction lesson where students had a chance to explore with the virtual pattern blocks, or the actual blocks, define each type of symmetry that the students will be expected to identify throughout the unit using the site: http://www.mathsisfun.com/geometry/symmetry.html. Following each type's description, stop and have students create a simple piece of art the shows each type of symmetry. Your students can create reflection symmetry, by one student drawing half of a simple picture or figure for a partner to finish the other half of the picture to make it symmetrical.

After discussing rotational symmetry, students can create "snowflake" designs (see below for examples) to show a shape and its rotational order.[8]





Following the discussion of point symmetry students can draw pictures of playing cards or the letters that display point symmetry.

Day 3:

After students have developed a clear understanding of those concepts from the introduction activities, then present the students with artwork and images that display symmetry or congruency. Have students work in small groups to determine and identify whether their given pieces show symmetry or congruent figures. A way to differentiate the groups and content, you could group students according to level and give the higher

performing students examples of point or rotational symmetry. Students who are working at or below grade level can work with examples that show reflection symmetry and congruent figures. Pieces should be laminated so students will be able to draw lines of symmetry, points of origin or rotation order directly on the example, helping them determine if it is in fact displaying symmetry. There should be examples of pieces that do not show symmetry so that students will have experiences finding non-symmetrical figures as well. After the groups have discussed and come to a conclusion about their artwork examples, they will present their reasoning to the class for discussion.

Day 4:

After the discussions on symmetrical and congruent figures from the artwork pieces, have students look in and around the school for artwork and parts of the architecture that use or displays symmetry and/or congruency. You may need to discuss what would constitute as artwork, so the students understand that paintings, photographs and 3-D figures are all considered pieces of art. Showing students images of the sculptor George W. Hart's work, (see below) would be great examples to display as they are geometrical and symmetrical.

 [9]

Examples the students may find are doors, windows, cupboard doors, picture frames, patterns in floor tiles, etc. After they have had time to explore and find examples, gather back together and discuss their findings.

As a way to help students further understand and be able to identify symmetry in architecture, students will use geoblocks to create symmetrical buildings. [10] They will use rectangular prisms, cubes, and triangular prisms in their constructions. Again, pair students together to have one student build half of the building and the other finish it making sure it is symmetrical. It may be helpful to display images such as the one shown on the next page to give students a better understanding of what symmetrical architecture looks like.

 [11]

Following the building activity, inform students that their homework will be to look around their homes for artwork/figures/architecture in which they find symmetry or congruent figures. They will then have to create a "quick sketch" of what they found to share with the class the next day. Again, it may be helpful to show images like the one shown below to give students an idea of symmetrical items they may find in their homes. This particular image not only has a symmetrical mantle, but the animal skull, chairs, pillows and the rug all have symmetrical features about them

 [12]

Day 5:

Students will come to class with their completed "quick sketch" example of symmetry or congruent figures that they found in their home. Allow time for each student to present their sketch to the class. While the students share, the rest of the class will explore and identify through a group discussion how the examples display a type of symmetry or congruent figures. Once again, point out that these concepts can be found all around "their" world.

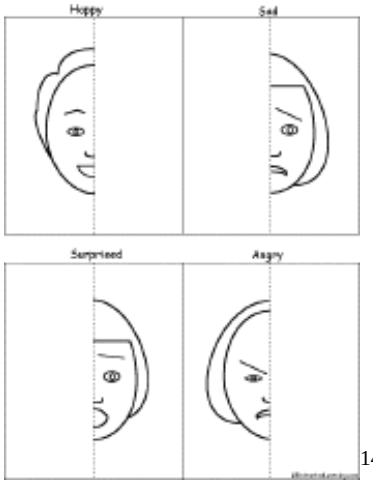
Day 6:

This activity could be completed in the classroom, or in the art room depending on how much access to art supplies you have and/or the availability of the art room. Students

will be asked to create a piece of artwork of their choice that represents the use of symmetry or congruent figures. Give students time to brainstorm and create a sketch of what they would like to create. Ideas that you could suggest (but are not limited to): Spiro graph drawings, (you would need a Spiro graph kit which can be found at an arts and craft store) coloring or creating mandalas printed from various websites,[13] making symmetrical designs with Perler Beads on pegboards. (you would need an iron to melt the beads together. See http://www.perlerbeadstore.com for more details.) or creating 3D designs with Legos, blocks, Unifix Cubes, or clay. It will be up to the students' level of creativity, artistic ability and understanding of the idea to decide what to create. It would be beneficial to hold short conferences with each student to discuss their ideas, and to ensure it is appropriate for the activity and uses symmetry and/or congruent figures.

Day 7:

Give students the time to create their design, image or other piece of art that they have chosen to make. Some may use the entire time given, and some may not. Early finishers could benefit from visiting websites like: http://www.adrianbruce.com/Symmetry/game/whiteboard-activity4.html where students can create a symmetrical design for a partner to replicate. (good to use with an interactive whiteboard) or www.abcya.com/shapes_geometry_games.htm and the National Library of Virtual Manipulatives at: http://nlvm.usu.edu/en/nav/topic_t_3.html if your classroom is equipped with computers for student use. If your classroom is not equipped with computers, use a symmetry worksheet similar to the one below or others that are noted in the appendix. Students could also complete more half drawings for a partner to finish.



[14]

.

Day 8:

Transform your classroom into an "art gallery" displaying the students' symmetrical artwork. You many even want to invite parents to come and view the "class art gallery" Students will be able to enjoy and critique the artwork as "mathematicians" by identifying which element (type of symmetry or congruency) the artist chose to represent. Each student will view all pieces of art and record what type of symmetry or congruent figures the artist chose to include in their artwork. After each student has had a chance to view all of the artwork, as a class we will discuss their findings and reasoning for their conclusions about each work of art.

Day 9:

The discussion of each piece of art may take more time than is available on day 7, so you may have to continue your discussion into day 8. When your discussion is completed, students will take a unit assessment on symmetry and congruency to ensure students have a full understanding of the concepts. This assessment can be found in the appendix.

At the conclusion of this unit, students will have a better understanding symmetry and congruent figures by making connections to the outside world. The students will also have applied what they have learned by creating their own pieces illustrating those concepts to show their full understanding of the information.

Appendix

In this section you will find helpful information about the websites, worksheets and assessment mentioned within the unit.

Symmetry video from www.linkslearnning.com

The video begins discussing the definition of line symmetry (which is the same as reflection symmetry). It mentions that symmetry can be found in nature, architecture and in art, which is an important introduction to the unit's focus. It also informs students what a line of symmetry is and that some figures have more than one. It then shows many different examples of symmetry as well as figures that are not symmetrical. After the information has been given, there is a practice activity that has students choosing if an

image that is shown has a vertical, horizontal or no line of symmetry. Following the quiz, the video continues to inform students that there is symmetry found in the letters of the alphabet. Then there is another practice activity for identifying lines of symmetry. After the second practice activity, the video shows how street signs have symmetry and how certain plane shapes do not have symmetry. The practice activity following that section has students choosing the correct line of symmetry out of three possible lines shown on the image or figure. The final practice activity has students finishing an image by choosing its symmetrical match.

National Library of Virtual Manipulates site

http://nlvm.usu.edu/en/nav/category_g_1_t_3.html This site has many different activities that your students can use. After reaching the website, students will need to scroll down until they find the word *transformations-reflections.* They will click on the words and then will be able to create objects with pattern block pieces and explore reflection symmetry. The site allows students to move the mirror-line and place and move objects in workspace that are immediately reflected.

Students can also use the geoboard link to make symmetrical shapes for a partner to replicate. The activity has students drag a "rubber band" to the board just as they would with a geoboard at their desk. Another link students could experiment with is the pattern block link. They could work with a partner and create half of a design for their partner to finish.

Shapes! from: http://www.abcya.com/second_grade_computers.htm

Shapes! is a game to help children learn basic properties of simple geometric figures. Children will practice looking for differences and similarities between shapes to complete puzzles. This game starts out very simple and gets progressively more difficult as children complete the stages. The final stage introduces symmetry.

Symmetry worksheets

The worksheet shown within the unit and many others can be found on websites such as enchantedlearning.com and superteacherworksheets.com.

Name:_____

Symmetry Assessment

1. Reflection symmetry is:
    a. Shown when something is identical on both sides
    b. A mirror image
    c. Found with a line of symmetry
    d. Both b and c

2. A line of symmetry can be in an direction: true or false

3. Rotational symmetry is:
    a. When a shape can be rotated
    b. Found only in circle designs
    c. Found when an image or shape remains the same after being rotated

4. Point symmetry is:
    a. Can be found on playing cards, snowflakes and some letters
    b. When a shape has points
    c. When every part of the shape has a matching part that is the same distance from the central point, but is in the opposite direction
    d. Both a and c

5. Draw a picture showing reflection symmetry. Be sure to show the line of symmetry.

Materials Needed for this Unit

Images of symmetrical art and architechure (laminated)

Geoblocks; rectangular prisms, cubes, and triangular prisms of various sizes

Geoboards and rubber bands

Paper and scissors

Pattern blocks

Perler Beads and iron

Spirograph kit

Notes:
[1] http://signiscambodia.files.wordpress.com/2008/08/picture-2651.jpg
[2] http://www.graphics.cornell.edu/online/mandala/
[3] Sautoy, Marcus Du. "May: Exploitation." In Symmetry: A Journey into the Patterns of Nature. New York: Harper Perennial, 2009. 276-277.
[4] "Nouvelle page 1." mandalarbre page 1. http://mandalarbre.com/volume_2.htm
[5] http://www.mathsisfun.com/geometry/symmetry-point.html
[6] http://www.mathisfun.com/geometry/symmetry-point.html
[7] http://www.linkslearning.org/Kids/1_Math/2_Illustrated_Lessons/4_Line_Symmetry/index.html
[8] Idea and images from: http://www.adrianbruce.com/Symmetry/12.htm
[9] Image from: http://www.georgehart.com/sculpture/sculpture.html
[10] Idea from 2nd grade Math Investigations Unit 2 teacher's manual
[11] Image found at: http://art.nmu.edu/cognates/concepts/pix/symmetry_arch.jpg
[12] Image found at: http://www.housebeautiful.com/media/cm/housebeautiful/images/4-barsanti-living-room-0608-xlg-51815101.jpg
[13] http://mandalarbre.com/volume_2.htm, http://www.abgoodwin.com/mandalamaker/
[14] Worksheet found at: http://www.enchantedlearning.com/finishdrawings/symmetry/indexfourpix.shtml

Annotated Bibliography

Bruce, Adrian. "Symmetry Webquest - Learn All About Line Symmetry - Lines of Symmetry & Rotational Symmetry." Adrian Bruce's Educational Teaching Resources-Reading Games-Math Games-Educational Software-Motivational Posters-Line Symmetry-Readers Theater-Art Lessons-Science Lessons-. http://www.adrianbruce.com/Symmetry/ (accessed October 3, 2010).
This site is very informational for both teachers and students. It has many activities you can use as a class or for individual students. It also has a webquest students can do on symmetry.

Hart, George. "Geometric Sculpture of George W. Hart, mathematical sculptor." George W. Hart --- Index. http://www.georgehart.com/sculpture/sculpture.html (accessed November 29, 2010).
Wonderful site to show students how sculptures can be symmetrical.

"LINKS Learning for Kids: Math: Illustrated Lessons: Line Symmetry." LINKS Learning. http://www.linkslearning.org/Kids/1_Math/2_Illustrated_Lessons/4_Line_Symmetry/index.html (accessed October 3, 2010).
This is a great video that provides a informational introduction to symmetry.

"Mandala Gallery." PAETEC. http://www.netreach.net/~nhojem/mandala.htm (accessed October 3, 2010).
This site is a great site to show students what Mandalas look like and to be able to view rotational symmetry.

"Nouvelle page 1." mandalarbre page 1. http://mandalarbre.com/volume_2.htm (accessed October 3, 2010).
This is another site that shows images of Mandalas, but also has 24 printable pages for students to color and create rotational symmetry.

"Order of Rotational Symmetry - Geometry - Math Dictionary." Mathematics Lesson

Plans, Answer Math Problems, Kids Homework Help, Free Elementary, Math Worksheets,Math K-12. http://www.icoachmath.com/SiteMap/Order_of_Rotational_Symmetry.html (accessed October 3, 2010).
This site is similar to an online dictionary that defines rotational symmetry and describes how to find it. It is a great teacher site.

Pierce, Rod. "Symmetry - Reflection and Rotation." Math is Fun - Maths Resources. http://www.mathsisfun.com/geometry/symmetry.html (accessed October 3, 2010).
This site is very student friendly and can help in your delivery of the different types of symmetry. It defines each type and has great images as well.

Powell, Nancy. "TeachNet -- Symmetry All Around You - Point Symmetry ." Teachers Network. http://teachersnetwork.org/dcs/math/symmetry/Point/ (accessed October 3, 2010).
This is another informational website that clearly defines point symmetry. It also has good images as examples of point symmetry.

"Rotational Symmetry." ICTeachers - Home Page. http://www.icteachers.co.uk/children/sats/rotational.htm (accessed October 3, 2010).
This is a step-by-step description of rotational symmetry with images that ehance the explaination. This is teacher and student friendly.

Sautoy, Marcus Du. "May: Exploitation." In *Symmetry: A Journey into the Patterns of Nature*. New York: Harper Perennial, 2009. 276-277.
In this chapter the author describes Mandalas and what they are and where they originated from.

"What is Symmetry?." Museum of Harmony and Golden Section. http://www.goldenmuseum.com/0501symmetry_engl.html (accessed October 3, 2010).
This is a site with an overview of reflection symmetry and has a few images.