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Introduction

Symmetry is a fundamental part of geometry, nature, and shapes. It creates patterns that help us organize our world conceptually. We see symmetry every day but often don't realize it. People use concepts of symmetry, including translations, rotations, reflections, and tessellations as part of their careers. Examples of careers that incorporate these ideas are artists, craftspeople, musicians, choreographers, and not to mention, mathematicians.

It is important for students to grasp the concepts of geometry and symmetry while at the elementary level as a means of exposing them to things they see everyday that aren't obviously related to mathematics but have a strong foundation in it. According to the National Council of Teachers of Mathematics grades 3-5 should be able to apply transformations and use symmetry to analyze mathematical situations. This includes predicting and describing the results of sliding, flipping, and turning two-dimensional shapes. They should also be able to describe a motion or a series of motions that will show that two shapes are congruent, and identify and describe line and rotational symmetry in 2 and 3-dimensional shapes and designs. The Montana State Standards for Mathematics are in line with NCTM's standards indicating that by the end of grade 4 students will be able to identify lines of symmetry, congruent and similar shapes, and positional relationships.

Geometry software is a very important tool in developing and testing individual ideas in the classroom. Students can make their own conjectures and "see" them as they are tested, making a connection between what they were thinking and a visual for what is really happening. For a lot of students this is all that is needed to make something "click" inside their heads that tells them "oh, yeah, now I get it".

By showing students that symmetry and it's properties surround us in the world we live in gives them a greater appreciation for the wide-reaching arms of mathematics and how we really do use math throughout our lives beyond the basic adding, subtracting, multiplying, and dividing. We can use dynamic geometry software to let students explore and create the concepts that we are trying to teach. Students will soon be pointing out symmetry and visualizing how shapes move around in our world.

Literature Review

There are several articles in mathematical journals, written by professionals in the field, which expresses the need for teaching symmetry and its properties as a part of the math curriculum at the elementary level. Several articles focus on the different ways of teaching the same concepts and others concentrate more on the tools we have available that link us to technology. All of the articles that I have come across support the understanding that symmetry is all around us and although it doesn't seem to be mathematical it's very roots are buried there.

According to Pumfrey & Beardon (2002), art and math go hand in hand. The connection has been there for a long time as we can trace the inspirations of mathematicians as a "product of the Islamic civilization brought to Europe by the Arab conquests in Spain in the thirteenth century". This relates specifically to tessellations that are a result of rotating, reflecting, and sliding objects in a plane so that there are no gaps or overlaps. Pumfrey & Beardon (2002) sum it up when they state "tessellations are a common feature of decorative art and occur in the natural world all around us."

When the students in Mackrell's (2002) temporary class were given the chance to explore the creation of polygons using geometry software they were creating a lot of abstract patterns that were commonly symmetrical. Mackrell (2002) found that many of the students were concerned with filling in the gaps of their patterns. She concluded that while she was not attempting to teach or emphasize any particular area of mathematics, "ideas regarding size, symmetry, tessellation and representation of 3-D objects were arising spontaneously and, given more time, could have been further developed" (Mackrell, 2002). Mackrell (2002) provides an easy way of introducing the topic of symmetry by taking what students create on their own with no instruction and showing them what they have created and how they did it in mathematical terms.

Gibbon (2001) also likes the idea of using dynamic geometry software as a visual learning tool in the mathematics classroom (Gibbon, 2001). Her first objective was to "first and foremost to enable the students to build on their previous knowledge of rotation and extend their skills in the topic with confidence and enjoyment". She wanted students to be able to do the activity by hand using the computer as an active helper. Her entire article focuses on two lessons in rotations, the second one building on what students learned in the first lesson. The activities presented could easily be expanded on and give rise to other symmetrical concepts such as translations and reflections.

Seidel (1998) applies geometry and symmetry to everyday life for 2nd and 5th graders. Second graders are offered the opportunity to use a program called SuperPaint to create symmetrical flowers and then copy them to make a garden. This lesson gives students a chance to solve their own problems and learn from each other. The fifth graders were introduced to Geometer's Sketchpad and used this program to create symmetrical snowflakes. It requires them to use the concepts of rotation and reflection, and makes it easy to tie in the idea of translations and how all three are related. This article is a prime example of one way in which symmetry is part of our everyday lives. There is a great biographical picture book, called *Snowflake Bentley* that would be a wonderful starting point for this lesson as it explores Wilson Bentley's intense interest in snowflakes and how each one is different.

There is a lot of children's literature available to teach many of the different concepts that math embraces including geometry and symmetry. Harris (1998) focuses a lesson on transformations using the book *A Cloak for the Dreamer* by Aileen Friedman. It contains links to tessellation, tiling, and symmetry and incorporates the importance of predicting, guessing, and thinking of all possible solutions for a problem, ultimately finding the best answer. Using literature as a teaching tool captures the students' attention and engages them in the learning opportunity at hand. It also gives kids a chance to build on their previous knowledge and apply what they know to learn more, coinciding with Mackrell's (2002) idea that these concepts will come out of little instruction and a lot of exploration. Harris (1998) also wants students to be able to create their own designs and then verbalize what they did using mathematical terms giving other students a chance to hear and see the concepts over and over again.

Finally Dolinko (1996) revisits the idea of symmetry in our world once again, this time using flags that represent countries from around the world. She talks about how we can talk about patterns in the arrangement of colors within each individual flag, identify geometric shapes, and compare their sizes. Studying the symmetry in flags from around the world not only gives us an avenue to explore symmetry and tessellation but it also links us to social studies and the similarities among countries when it comes to how they want to be represented by the design of their flags. Using Dolinko's (1996) deas for a math lesson could be incorporated as a wrap up

to symmetrical concepts and a link into a social studies lesson on similarities and differences in countries. It also builds on what students have learned already and gives them a chance to take what they learned using geometry software and putting it on paper in a meaningful way by creating their own flags.

Allowing students to explore and create on their own using the ideas and concepts of geometry and symmetry leads to higher level thinking. Using dynamic geometry software we are giving students a hands-on experience that allows them to visualize and come to an understanding of what is happening in their own minds, and teaching them how to apply that understanding to the concepts of math. We can spark interest in the concepts being explored by using literature to invoke questioning and answering and by discussing what we see in our everyday lives that illustrate symmetry, tessellation, and tiling. Translations, reflections, and rotations give us an idea of how patterns are made and how objects move in space without changing the object itself. The ideas presented in all of the mentioned articles take motion geometry and tessellation to a higher standard and one that should not be passed up in the elementary math curriculum.

Activities
Activity 1

The following activity is based on a lesson in the article by Seidel (1998) mentioned in the literature review. It incorporates using children's literature as an avenue of understanding concepts of symmetry. Geometer's Sketchpad is also used as a manipulative tool allowing students to visually do and see in order to understand the presented topic.

Overview and Purpose: The purpose of this lesson is to use literature as an example of how symmetry occurs in everyday life and to expand on it using a computer program to create snowflakes of our own creation, showing and using the mathematical terms presented.

Objective: Students will be able to apply the terms they learned in a previous lesson, relating to rotations, reflections, and translations, to create symmetrical snowflakes using the program Geometer's Sketchpad.

Materials: One computer for each student that has Sketchpad software available for use, scratch paper for each student, and *Snowflake Bentley* by J.B. Martin.
Instructional Procedure: Start the class out by having students do a quick review of what they already know and what they have learned previously. Answer any questions that may arise and brainstorm with the class things that we see everyday that employs the concepts of symmetry.

Next, read the story Snowflake Bentley to the entire class, focusing on the pictures and the sidebars of information provided beyond the text of the story. By reading this story aloud and using it as a discussion tool many students will become actively involved and want to try some things out on their own. Explain that they will be able to explore creating some snowflakes on their own using Geometer's Sketchpad and give a brief overview of the program, being sure to include instructions on how to rotate, reflect, and translate.

The idea is to let students create snowflakes that are symmetrical but by doing it on their own, learning as they go, and writing down the steps they take to get the figure they constructed. This helps students become more familiar with the mathematical language that they have already been exposed to relating to symmetry.

<u>Assessment</u>: Each student will be responsible for making at least 5 different snowflakes and using the text box tool they will provide a description of their snowflake using mathematical terms to describe how they got their final result. Each student will then share his/her ideas with the rest of the class, exposing everyone to ideas that they may not have thought of on their own.

<u>Standards Addressed with this Activity</u>:
National:
1. Identify and describe line and rotational symmetry in two-dimensional shapes and designs.
2. Predict and describe the results of flipping and turning two-dimensional shapes.
3. Build and draw geometric objects
4. Create and describe mental images of objects, patterns, and paths
5. Describe location and movement using common language and geometric vocabulary
State:
1. Explore properties and transformations of geometric figures
2. Use geometry as a means of describing the physical world

<u>Activity Two</u>
The next activity could be used at the end of a unit on symmetry and tessellation. It will require students to use their knowledge base to create their own designs by applying properties of symmetry. This activity is connected to all of the literature reviews because it examines symmetry and patterns in everyday life and allows for self-exploration in the creation of something that will represent each individual student.

<u>Overview and Purpose</u>: The purpose of this lesson is to connect geometry and symmetry to things involved in our everyday life. Students will actively apply what they have learned during this unit to create a final symmetrical or tessellation project, reflecting the concepts and ideas presented.

<u>Objectives</u>:
1. Students will be able to apply what they have learned to create a flag that is unique and uses many of the types of symmetry they have been exposed to.
2. Students will be able to visualize their flag and transfer that visualization into a meaningful creation on paper.
<u>Materials</u>: Almanac with examples of flags from around the world. Scratch paper for students to get the rough draft of their own flags started. A printed copy of all the things discussed during the unit and a definition for each along with rules that apply symmetry and tessellation, construction paper, markers, crayons, glue, etc. (Students may use any medium they would like to create their flags). Make sure there are computers available for those who would like to use Geometer's Sketchpad as a tool in helping them create their own flags.

<u>Instructional Procedure</u>: Begin class by asking students to look at almanacs in groups of 3-4 and have them write down the shapes, colors, ideas they see that are common and unique to flags from around the world. Students should be able to identify the patterns of the shapes used. After creating a list the class will come together and share their ideas and what they found. Leave these ideas on the board for students to refer to while they create their own flags. Some students

may want to test out the picture in their heads by using Sketchpad and experimenting with that until they are ready to transfer it to paper. Students should be focusing on what shapes they are using, patterns they are making, and using mathematical terms to describe how they created the patterns they have chosen. The flags should be unique and representative of the student.

Assessment: Each student's flag must contain at least 2 types of symmetry. On the back of each student's flag there will be a description of the types of symmetry used and what the colors and shapes represent for that particular student. Students will also write about what they learned from this assignment and in what ways, other than those discussed symmetry, could be used in everyday life.

Standards Addressed with this Activity:
National:
1. Identify and draw a two-dimensional representation of a three-dimensional object
2. Predict and describe the results of sliding, flipping, and turning two-dimensional shapes
3. Identify and describe line and rotational symmetry in two-dimensional shapes and designs
4. Describe a motion or series of motions that will show two shapes are congruent
State:
1. Investigate and predict results of combining, subdividing, and changing shapes
2. Identify lines of symmetry, congruent and similar shapes, and positional relationships
3. Understand and apply geometric properties and relationships
4. Explore properties and transformations of geometrical figures

Conclusions and Implications:
    Teaching symmetry in the elementary classroom is very important because it allows children to understand the things they see every day in a different context. It allows children to follow the rules to create their own patterns, and this in turn, allows them to discover what they do and do not like, motivating them to make things better. This area of geometry brings together life and mathematics in a more meaningful way that is not so concrete. Students will often forget while they are studying symmetry and its properties, that they are doing math and it will become a more enriched experience.
    I hope that students will gain an understanding of what symmetry and tessellations are and what they mean to us. I would like to see students adding to their previous knowledge base by expanding on what they already know to understand more mathematical properties in greater depth. I think that by applying the properties and types of symmetry to everyday life through literature, snowflakes, and flags students will begin to see math everywhere and as an important part of how we function and see things
    Technology can enhance the symmetrical experience by giving students hands-on experience with manipulating objects to create patterns. Students who learn visually will benefit greatly from the use of dynamic geometry software that allows them to "see" what is happening (Gibbon, 2002). For those who learn through auditory using technology gives them a basis for discussions that reflect what they saw. Technology can make math come alive and can be the "aha" for someone who is struggling visualizing ideas in their heads.
    The lessons presented in this paper can easily be followed up with additional activities that explore the same concepts and ideas. There are several good picture books that can and should be incorporated into the math curriculum that expands on mathematical concepts (Moore,

2002). A preceding activity that may be done prior to the first activity mentioned would be reading *A Cloak for the Dreamer* which explores the geometric shapes and how they fit together so there are no gaps or overlaps. This is a great way to introduce a unit on symmetry to a class that may or may not have encountered the ideas before. For the second activity it would be easy to focus a future art lesson on tessellations and tiling that will require the students to refer back to what they have learned as a result of the unit on symmetry. It would be very easy to incorporate symmetry into every subject area of the curriculum because it is found everywhere and connects math and our lives in a way other concepts cannot.

Enriching the curriculum for more "talented" kids could be as simple as having them apply more than one transformation of an object to create patterns or prove different ideas. Many students can show that two objects are congruent by moving one object on top of the other, but talented students could delve further and be led to discover that by reflecting an object twice you end up with the original object through a translation. Students who were interested in learning more could have extra computer time using dynamic geometry software to explore and share in a group on their own.

Overall, students of all abilities and levels will benefit from learning about this specific area of geometry often referred to as motion geometry. Math will not seem like math in the traditional sense, but the ideas and concepts behind the activities will give students a real life connection to mathematics and the broad topics that it touches. It is important for students to be interested and excited about math on several different levels because it can relate to their own lives at any point in time. I hope that by studying symmetry students can make a connection between math and the real world with a deeper meaning and understanding, and not just something they "have" to do.

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