SYMMETRY FROM NATURE

TO THE CLASSROOM

"For children, geometry begins with play..."

~ Pierre Van Hiele

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The purpose of a teacher is to enrich a child's mind; a teacher should contribute to a student's ability to think independently and creatively, make decisions, and solve problems. In order to do this, students should be allowed to practice these skills in the classroom. The active learning approach allows students the opportunity to explore the material and enhance their education. With mathematics having such a vast range of applications, a math classroom allows the perfect opportunity for this learning exploration. The active learning method coincides with the National Council of Teachers of Mathematics (NCTM) view that students should be involved and actively participating in their own education, as opposed to simply sitting at the desks. The van Hiele theory of math education gives insight into how students learn math, particularly geometry, and also has solid ties into active learning. Geometric symmetry is a part of math that we can see in the world around us no matter where we look, from the molecular level to our own bodies and the survival of animals. To illustrate active learning, the van Hiele method, the NCTM vision for math, and the symmetry that we see around us in the environment, I have compiled seven activities. These activities focus on the middle school grades, from 6th through 8th, and allow for students to play an active role in their education. They are based on a quote by Pierre van Hiele: "For children, geometry begins with play."

Guided learning is the traditional method of instruction that we see in most mathematics classrooms. In this type of instruction, the teacher leads the students through the steps they should follow, and is very teacher-oriented. In a classroom that follows this type of instruction, there is minimal interaction between the students and the material, and little exploratory learning. According to Alison King, an education professor in the College of Education at California State University, this style, "will not be effective when individuals will be expected to think for themselves, pose and solve complex problems, and generally produce knowledge rather than reproduce it." Students learn in different ways, so this should not be the only method of instruction that is used. A different approach to education, then, is active learning. The active learning approach uses instructional methods that require the learner to play a larger role than is offered with guided learning.

Active learning incorporates meaningful activities that require students to think critically and problem solve and is designed around the expected learning outcomes. While participating in activities the students need to be aware of the goal they are working towards; this will allow them to be fairly self-directed and find the most success. The students are engaged in the activity so that they are processing information, problem solving, and thinking creatively while they are participating. The students should constantly be building on prior knowledge and relating new material to familiar information. Students will often work in groups, which will enhance their cooperative learning and discussion skills. Not only does discussion result in better retention of the material, but active learning in itself leads to improvements in student attitudes and motivation as well as their general thinking and writing skills (Bonwell and Eison, 3).

The van Hiele education theory offers a link to the active learning method in a math classroom; it provides a description of the way students learn geometry, and also gives insight into the benefits of geometry for students. In the 1950's, husband and wife mathematics teachers from the Netherlands, Pierre and Dina van Hiele examined their students' learning habits and "geometric maturity," and created a geometric model of thinking from their research. In the 1960's, the Soviet Union adapted their findings into a curriculum, but other than that, their doctoral work did not gain much attention right away. In the 1970's an American, Izaak Wirszup, began working with the model, and its reference in a few publications brought it to the public eye. From there, the interest in this model was increased, and has become quite popular.

This model consists of five levels that students progress through when learning geometry, numbered from 0 to 4. As students progress through these levels and gain an understanding of geometry, they develop divergent thinking skills as well as the ability to visualize geometric concepts. Level 0 is best described as the Visual Period, which occurs around the early elementary years. At this level, students are able to learn geometric vocabulary, can identify basic geometric shapes, and can reproduce these shapes. For example, children could point out a square and draw a picture of it. They would not, however, recognize that this figure has 90° angles or parallel sides. At this level, students should be working with sorting, identifying, and describing shapes. They should be working hands on to create and manipulate physical models through building, drawing, putting together and taking apart shapes. Students should examine different sizes and orientations of the same shape so that they can begin to distinguish defining characteristics of the shape, and also features that are irrelevant.

Level 1, known as the Analysis Stage, is when students will observe, manipulate, and experiment with geometric shapes and properties, in order to identify differentiating features. At this stage, they should shift from simply recognizing the shapes to also identifying the properties of these shapes. The students should be able to define and make lists of the properties of a given shape, and discuss the necessary conditions to classify a shape. For example, students can fold different squares to see that the sides of each one are the same length and all of the angles are the same and they can then list these as the defining characteristics of a square. They will now move from identifying shapes purely on the visual aspect, but also by their properties. At this level, however, they will not yet be able to see the relationships among properties; for instance, if the opposite sides are parallel then opposite angles are congruent. Interrelationships between shapes are also not yet identifiable; for example, students will not recognize that a square is a rectangle.

In level 2, which can be labeled Informal Deduction, students can use geometric properties to make these connections both between the properties of one shape and also make connections between different shapes. They can use both models and lists of properties and discuss which properties are necessary for a specific shape, then use this to investigate the relationships among shapes. The students do not fully understand deduction yet, but can use informal arguments and problem solving to analyze geometric properties and their uses and relationships. At this stage, they should also have the ability to find generalizations and counterexamples. Students should be able to follow a formal proof, but will not be able to complete one on their own. This stage occurs during the middle school years.

In level 3, Deduction, students will recognize that deduction plays a significant role in establishing geometric theory and the concept of an axiomatic system is understood. They can see the correspondence between undefined terms, axioms, theorems, definitions, and formal proof. Additionally, they can distinguish between a statement and its converse. Students should be able to construct formal proofs and understand that a proof can be developed in more than one way. Most high school geometry courses are taught at this level, and this is usually the highest level attained by students.

Level 4, Rigor, is the highest level and is not achieved by all learners. At this level, geometry is seen as abstract. One will reach an understanding of the different axiomatic systems of geometry, and be able to study and compare them. In the original work of the van Hieles, this level was the least developed, and Pierre van Hiele admitted that he was most interested in the first three levels. Due to the rare acquisition of this stage, little research has been done since then.

As the instructor assists students in advancing from one level to another, there are things they must keep in mind. The progression needs to occur sequentially, meaning the students must go through the levels in order. For a student to function at one level, they must have acquired the strategies of the previous level. Also, student progress depends more on the content and method of instruction than it does on their age. If a student is not being challenged, their advancement may be hindered, while a student who is engaged and encouraged to participate in their learning is more likely to move forward. It is important to remember that a student's learning is continuous and constructive; they are building on previous knowledge. Additionally, each level has its own linguistics and relations. For example, in one stage a square will be a square and just that; in the next stage a square is also a rectangle. Lastly, it is of the highest importance to know what level the students are at so the instruction meets their needs. If the students and instruction are not at the same level, appropriate understanding will not occur.

In order to move students from one level to another, the van Hieles recommend incorporating the following phases into each lesson or activity:

1. Inquiry/Information
2. Guided Instruction
3. Explication
4. Free Orientation
5. Integration

It is most beneficial to begin the activity with the first phase, Inquiry/Information. This should take place almost as a conversation between the teacher and students. Teachers should ask questions of the students, introduce vocabulary words, and allow students to make observations. This will give teachers an idea of what the students know already. Also, providing the students with information helps students see the direction they will be going. The next phase, Guided Instruction, uses tasks and materials that the teacher has carefully chosen to relate to the material. In this, students are given examples to work with that relate to and prepare them for the work they will be doing later. These examples shouldn't be lengthy, but they should provide the students with a glimpse of what is to come. Phase 3 of each activity, Explication, goes hand in hand with phase 2. In this, the students should be discussing the examples they are working with and expressing their observations. During this phase, the teacher should make sure that the students are using the correct vocabulary and language, and clear up any misunderstanding so far.

Free Orientation, phase 4, is where the students have an opportunity to explore the material using more complex tasks. The students should be gaining experience, participating in the activity and working towards resolving the task set before them. As they do so, they should be justifying and explaining their findings. The final phase is Integration. Here, a summary of the activity occurs when the class comes together and discusses their findings. A conversation should take place, giving an overview of new relations that were found, giving explanations and relating to the original information given. A review of the information occurs, but nothing new should be introduced at this time.

A study done by Erdogan, Akkaya, and Celebi Akkayaa, in 2006 analyzed the effect of the van Hiele model using 6th grade students. This study consisted of delivering instruction to a control group and an experimental group and analyzing the results according to the creative thinking levels of the students. To begin, each group took the Shapes Section of Torrance Creative Thinking Test; this is the most commonly used creativity test and has a reliability coefficient of .90. A three-week geometry unit on angles and triangles was delivered to each group. The experimental group received active learning instruction based on the van Hiele model, while the control group received instruction using the guided learning method. In the experimental group, the students participated in discussions, group work, cooperative learning activities, experimenting, and relating material to previous knowledge. This group also used tools such as a GeoBoard, compasses, protractors, tangrams, and other hands on manipulatives. After this three week period, the students were again given the same test. Upon examining the results, there was a significant difference between the pretest and post test scores of the experimental group. Their scores showed improvement in fluency, originality, and abstraction. The test scores of the students in the control group showed no significant change in any of their creativity levels.

The National Council of Teachers of Mathematics, is "an international professional organization committed to excellence in mathematics teaching and learning for all students," (Principles and Standards for School Mathematics, pg. *ix*). The vision of this group is to bring to all students "high-quality, engaging mathematics instruction," (pg. 2) which also falls directly on the lines of active learning. This council works to bring resources, including technology and interactive lessons, to math teachers that can benefit their classrooms in many different ways. Their goal is to make math classrooms more exciting and motivational for students; their principle of learning insists that students gain understanding by actively building upon prior knowledge. In addition to providing resources, NCTM also has a set of standards that describe what students should be able to do as a result of their instruction. These standards cover the mathematical content areas of number and operations, algebra, geometry, measurement, data analysis and probability as well as the processes of problem solving, reasoning and proof, connections, communication, and representation. A quote from the NCTM website states, "Most of us have to follow state or district requirements but with some creativity and work, we can meet the state and district requirements while making math interesting, engaging, and attainable for our students." One of the most important ways to do this is to relate the material to something students find interest in.

The word geometry is derived from the Greek word, geometric, meaning "earth measure." The subject of Geometry, then, obviously has incredible ties to the natural environment, which many students find interesting. Of course, symmetry, being a fundamental part of geometry also occurs naturally in countless places, from ice crystals, to spider webs, butterflies, and beehives. Symmetry is not only beautiful and eye catching but it also has many practical purposes, such as speed and survival. For instance, animals that possess bilateral symmetry are able to run faster, allowing better chances of survival; symmetry in living organisms is also an indicator of good health. Most students have prior knowledge of the environment, and all students have some relation to it, simply by being alive. Symmetry in nature is a great example of an exciting way to tie in mathematical concepts with something students can explore, investigate, and interact with. I have chosen to compile activities that focus mainly on the symmetry of starfish, ice crystals/snowflakes, flowers, beehives, and humans, as well as objects the students find. These activities work with line or reflective symmetry and rotational symmetry and follow the active learning approach. They will provide information explaining the mathematical properties of both types of symmetry, along with the benefits of symmetry in our environment. In the activities, students will search to find objects that contain symmetry, find symmetry in objects, have opportunities to create their own objects with symmetry, and discuss their observations and hypotheses along the way.

I have created seven activities that work with the topic of symmetry and relate it to nature; these are to be used in the middle school classroom setting. The outline of each activity is based on the van Hiele phases for transitioning from one stage to the next and each should contribute to a student's growth in both van Hiele level 1 and level 2, Informal Deduction. To begin with, the activities offer new information about the topic, or a review of old material (phase 1, information/inquiry). The students are then given examples to work through and discuss together in class (phase 2, guided instruction). With these examples, any more important information, key concepts, and vocabulary words will be brought up (phase 3, explication). Students are then given a task to accomplish. They are given guidelines to follow but are encouraged to problem solve and think creatively in order to reach their goal (phase 4, free orientation). Each activity is concluded with a summary consisting of presentations, and/or class discussions. Questions should be posed to highlight the key concepts and make sure that the objectives were met.

These activities are not meant to be used as a unit lesson plan, or as the only method of teaching symmetry in a classroom. Some of the activities overlap, but also give a different perspective on the topic. Each activity is simply meant to supplement a lesson or two from a unit on symmetry, and provide a new perspective for students to view this branch of mathematics, as well as allow them to think creatively about the subject. Create Your Own Environment, Create Your Own Star, Snowflakes, and Symmetric Search: Rotational Symmetry all satisfy the NCTM standard stating that students should be able to "draw geometric objects with specified properties." The standard in which "students use symmetry to analyze mathematical situations" and also the standard stating that "students should recognize and apply geometric ideas and relationships in areas outside the mathematics classroom such as art, science, and everyday life," are met by all seven of the activities. Each activity is meant to be interactive in the examples and discussions. The discussions should be guided by the teacher, but are not meant to be used as lectures and should contain quite a bit of input from the students. Each lesson can be adapted to be delivered by means of PowerPoint, Smartboard technology, or any other preferred way. Ideally, a classroom should work with activities like this that relate to the various interests of students, allow for creative ways to apply and assess mathematics, as well as integrate other tools such as technology and manipulatives.

The first activity is called Symmetric Search 1: Line Symmetry; this activity would best fit in either 6th or 7th grade. The lesson provides examples of line symmetry, first in different polygons, and then in objects found in nature. With these examples, the students are allowed some practice at finding lines of symmetry, as well as identifying objects that do not have line symmetry. These examples can be given to the students either on a work sheet, displayed on the overhead projector, or on a Smartboard. It is important to discuss with the students that when they see symmetry in nature, it won't be perfect like it usually is when we're examining shapes. When the students receive the assignment, which is to photograph objects in nature that contain symmetry, they should be shown an example of what they are being asked to do. If it is not possible to equip all of the students with a camera, there are other options, such as having the students draw their objects or print them off the internet. They should also be encouraged to be creative and find symmetrical objects that they haven't seen yet in the examples, or maybe aren't as common. This project will demand quite a bit of time outside of the classroom, so the students should be given plenty of time to accomplish it. It would be very beneficial for the students to take a class day to work outside and explore to get started finding objects. This way, they can clear up questions they may come across and receive more guidance if necessary. The summary of the activity has the students discussing where they found line symmetry and why it is important, for example: balance, speed, and agility. Many plants and animals have symmetric parts because each part grows at the same rate, and symmetry is a sign of health in most plants and animals.

The second activity is very similar to the first, and is also works best in 6th or 7th grade. This one is called Symmetric Search 2: Rotational Symmetry; it uses the same concept as the first and follows the same outline, but this time the students are asked to draw the rotational symmetries that they find in nature. The students again present their findings and discuss the benefits of rotational symmetry found in nature. Input from the students will probably fall along the lines of balance again, but it also goes further than this. For example, the cells in a honeycomb are in the shape of hexagons, which are very symmetrical. Hexagons in this situation provide the bees with the capabilities of storing the most honey in the least amount of space. Also, flowers that are more symmetrical produce more nectar, and therefore, are more likely to survive.

The third activity I created works with snowflakes; this activity is geared towards 7th or 8th grade students. Students are used to folding a piece of paper to cut out a snowflake, but this time, they are going to work together to create one in a way similar to how they are created naturally. To begin, this lesson describes the process of snowflake creation. A snowflake starts as the hexagonal lattice of an ice crystal, which develops facets as water vapor condenses on it. This hexagonal lattice now becomes a hexagonal prism, and as it is tossed around in the atmosphere, branches begin to sprout from the vertices of this prism. Since the atmospheric pressure and temperature are fairly constant around this frozen hexagon, the branches form very similarly to each other, eventually creating what we know as the snowflake. The students will be in groups of six; each group will have a hexagonal piece of plastic canvas and pipe cleaners. Each student will work at a vertex of the hexagon to create a leg of the snowflake. The goal is for the students to work together so that the arms are all symmetrical. At the end of the activity, students will discuss as a class how this compared to the natural formation of snowflakes. The discussion should include questions about the symmetry they created, the possibility of identical snowflakes, and the difficulties they came across. It is also important to touch on the team aspect of the activity and have students discuss the troubles they had as well as what they learned while working together.

My fourth activity is titled Bees; this is a shorter activity that can be used as a daily lesson for identifying types of symmetry and would probably best fit a 6th grade classroom. This activity gives students interesting facts about bees and their vision. Bees are not only color blind, but can't see very well in general. Due to this, they use symmetry as a means of finding flowers from which to collect nectar. Different types of bees are attracted to different types of flowers; for example, the

Honey bee finds flowers with rotational symmetry attractive, such as the Honeysuckle, Clematis, Daisy, and Sunflower. The Bumblebee, on the other hand, is attracted to flowers with line symmetry such as the orchid, sweet pea, and foxglove. Flowers that are more symmetrical are in a sense 'healthier,' and are able to produce more nectar; consequently these flowers attract more bees. This leads to the fact that flowers are more likely to survive if they are symmetrical. Students will probably point out that symmetrical flowers are also more pleasing to look at. This activity can stimulate great discussion about symmetry and its benefits and effects on both bees and flowers, from survival to aesthetics. The students should be asked to discuss their technique on distinguishing line symmetry from rotational symmetry in the flowers presented. Many will have noticed that the flowers with rotational symmetry also have many lines of symmetry. What they should notice is that the flowers used here with line symmetry don't have rotational symmetry; this can be used as an identifying factor in this activity.

The activity titled Symmetry and Balance is another activity that deals with the benefits and uses of symmetry and would work best with 6th or 7th grade students. The students will experiment with the symmetry of a spinning top, as well as the symmetry of their own body, to see how this affects different aspects. This project will also take less time than others, such as the Symmetric Search, and could be done in the duration of one class period. As students experiment with the spinning tops, they will notice that they do not spin as well with something taped to their side, and some may not spin at all. When the students wear one taller shoe, they will notice differences in their balance, they will not be able to jog as quickly, etc. The students should bring ideas like this to the discussion that takes place after the lab. This discussion can then turn to the symmetry of other animals. When students mention speed and balance again, they should be asked to elaborate. The example of a herd of deer can be used. The slower deer are less likely to survive if they cannot run fast enough to keep up with the herd. Not only are more symmetrical animals found more attractive than those that aren't, but they are also more likely to survive. Oftentimes, animals that are asymmetrical (do not have symmetry) are unhealthy in some way, again lowering their chance of survival. This concept goes both ways. If an animal is more likely to survive, it is also found to be more attractive, and therefore more likely to reproduce. This discussion allows students to think creatively when working towards these observations. They will use reasoning and problem solving, and are also tying in their learning with other subject areas such as science.

The activity titled Create Your Own Star is based off of the rotational symmetry of starfish. This can be used as a supplement to a section on rotational symmetry, or as a review of rotational symmetry, and would fit nicely in all three middle grades, 6th, 7th, and 8th. This activity is introduced through learning about starfish. As a class, students will explore examples of starfish and use pictures to figure out how many times the starfish can be rotated before it falls back into its original position. Students will learn that there are over 1800 different species of starfish, all of which are symmetrical and can have up to 24 legs. They will learn the uses of the starfish arms and their symmetry: housing vital organs, sensing prey, fighting, movement, and survival. If a starfish loses an arm, it has the ability to regenerate one that demonstrates symmetry just as the original arm did. Some species even have the ability to regenerate a whole starfish off of just one arm! Before beginning the activity, the students should be introduced to the term angle of rotation and its definition: the smallest angle the object must turn in order for it to coincide with the original figure. In their explorations, the students will be asked to find the angle of rotation and will rely on their previous knowledge to do so. The students will be provided with materials, in this case raw spaghetti noodles, cheerios, miniature marshmallows, and yarn to create their own 'being' that possesses rotational symmetry. During this lab, students are working to be creative while following guidelines. Once finished with their 'being,' they are to find its angle of rotation. The students can present and then display their projects when finished. In the presentations, they will describe their method of finding the angle of rotation. To summarize and check for learning, the students will figure out the angle of rotation in a starfish that has 24 legs. This activity really works on students in the creativity and problem solving aspects through creating their own symmetry and building on previous knowledge.

The next activity, Create Your Own Environment, can be used as a final project on a symmetry unit in any of the three middle grades. To begin the activity, students should review line and rotational symmetry. The students can offer examples that they have seen in nature that have these properties. The project will then require the students to create their own environment with symmetrical objects. They will be encouraged to be creative and use more than the familiar examples like butterflies, leaves, and snowflakes. In order to follow the guidelines, they will have to incorporate objects that have one to four lines of symmetry, and also objects with different angles of rotation. They are asked to label each type of symmetry and state either the number of lines of symmetry or the angle of rotation. With this activity being used as a final project, the students should feel comfortable enough with the topic to complete this. Again, they have a great opportunity to be creative with the environment they create and apply knowledge they have gained.

The last activity, 3-D Symmetry, has students working hands on with objects to find their axes of rotational symmetry. To begin, the students will look at a couple examples of objects and their axes of symmetry; the examples I have included are a cardboard box and a basketball. I have included pictures in the lesson plan, but ideally, these items should be brought into class so that it is easier for the students to move the objects around and see the axes of symmetry. For the activity, then, the students will be given an orange that has lines drawn on it to represent the slices on the inside. The students will use bamboo skewers and actually poke them through the orange to represent the axes of symmetry. This activity can also use other objects, such as a small cube, and have the students complete the same task. The final discussion should then cover how many axes were found, how many times the orange can rotate about each axis, and which were the most obvious, etc. The students can also be asked to think of other objects, particularly natural objects, which have axes of rotational symmetry. This activity should only be used in a class that would be respectful and responsible with the materials; it best fits either an advanced 7th grade or 8th grade classroom.

"The challenge in teaching is to create experiences that engage the student and support his or her own explanation, evaluation, communication, and application of the mathematical models..." (Drexel University, par. 3). A child's mind needs to be stimulated in ways outside of the traditional classroom setting. They should be allowed the chance to take an active role in their learning through different areas in which they find interest. When given this opportunity, they are more likely to find motivation, gain confidence in their work, and feel a sense of pride in their accomplishments in the classroom. Students learn better and are more likely to retain information when they are given the chance to explore the material themselves. Their work should challenge their creative thinking, problem solving, and reasoning skills to help these develop. As teachers, we have many resources available for helping plan active learning instruction, from organizations like NCTM and research such as the van Hiele model. We need to take advantage of the opportunity to benefit the learning of our students in the highest possible way. After all, according to Henry Steele Commager, "Students are not vessels to be filled, but are lamps to be lighted."

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Activities:

Interacting with Symmetry and Nature

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Activity: SYMMETRIC SEARCH: LINE SYMMETRY

Objective: Students will deepen their understanding of line, or reflective, symmetry. They will understand what it means to have more than one line of symmetry, and will be able to recognize this in objects. They will explore line symmetry by finding their own examples in nature.

Materials: Cameras (disposable, digital, or film), poster

<u>Review</u>

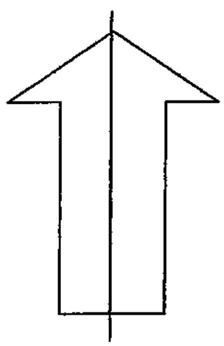
Line Symmetry

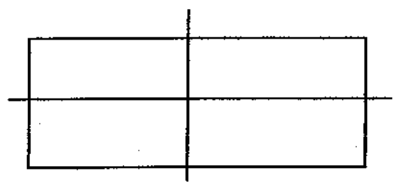
If a figure has line symmetry, it can be folded so that the parts match exactly.

Figures can have more than one line of symmetry.

Can you find the line(s) of symmetry in these objects?

Exs.

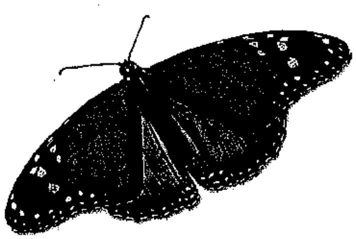


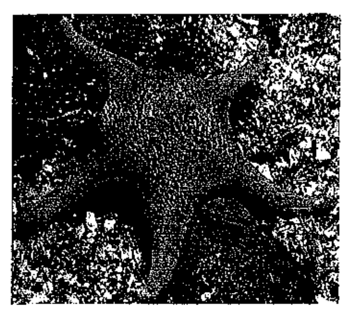


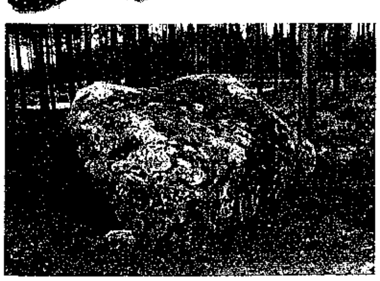
No lines of symmetry

Where else do you see figures with symmetry? Do you see any in nature?

Have students take turns identifying and drawing in lines of symmetry with these examples.







*Key concept: although the symmetry is perfect in many of the shapes we are used to seeing, this will not always be the case. When we are looking at things that occur in nature, there are different environmental factors that cause imperfections in the symmetry of objects.

Assignment

Students will find, identify, and take pictures of 10 different objects from nature (plants, animals, leaves, etc.) that have symmetry. At least 1 of these objects must have 2 or more lines of symmetry. On each picture, they will state how many lines of symmetry there are, and identify them. For the final project, they will display the pictures and their findings on a poster.

Offer one day of class time for the class to go outside and begin their search. This will allow students valuable work time, as well as a time to clear up questions about what is acceptable and what is not.

Summary

Students will present their findings in class.

Questions:

What were a few of the common objects that were found?

What were the most original objects found?

How is line symmetry beneficial to animals? To plants?

Why do you think plants and animals have symmetrical parts?

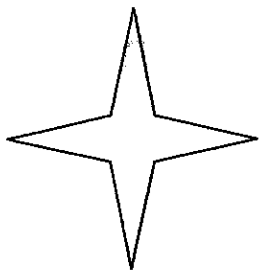
What do you think causes the imperfections in the symmetry?

Activity: SYMMETRIC SEARCH 2: ROTATIONAL SYMMETRY

Objective: Students will deepen their understanding of rotational symmetry. They will understand what it means for an object to have rotational symmetry, and how to determine the degree of rotation. Students will explore rotational symmetry by finding examples in nature.

Review

Rotational symmetry: After rotating a figure less than 360 degrees, it will coincide with the original figure. For example:

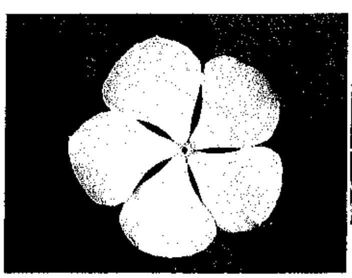


This figure will line up with itself 4 times before it is rotated one full time (360 degrees), which means it has 4-fold rotational symmetry.

Can you think of other objects that have rotational symmetry? Are there any in nature?

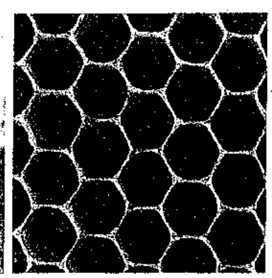
Examples:

Certain flowers (honeysuckle), spider webs, honeycomb



5-fold

~20-fold



6-fold or 3-fold

*Key concept: although the symmetry is perfect in many of the shapes we are used to seeing, this will not always be the case. When we are looking at things that occur in nature, there are different environmental factors that cause imperfections in the symmetry of objects.

Activity

Students will explore and find 6 different objects in nature that have rotational symmetry, and draw a picture of each one. At least 3 must have more than one rotation. The object in each drawing should be labeled, the rotational symmetry should be labeled and the students should state how many times the symmetry occurs in one full rotation (2-fold, 3-fold, etc.).

The class will use one day in the classroom to explore outside or research on the internet. This will give the students the opportunity to work, as well as to ask questions about different objects they are unsure of.

Summary

Students will present their findings in class.

Questions:

What were a few of the common objects that were found?

What were the most original objects found?

How is rotational symmetry beneficial to animals? To plants?

How did you find the degree of rotation?

Activity: SNOWFLAKES

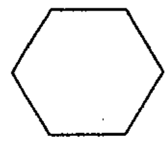
Objective: Students will see a relationship between symmetry and science. They will understand how ice crystals, and therefore snowflakes, are formed. They will work as a team to create a giant snowflake in order to better understand the process of creating symmetry.

Materials: Pipe cleaners, Styrofoam hexagons

Lesson

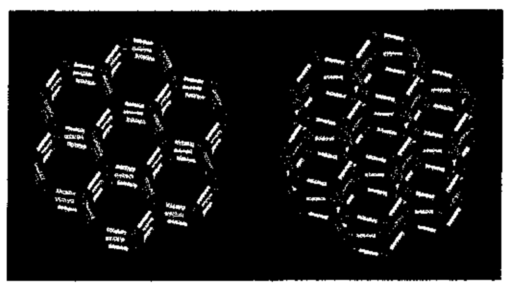
Snowflakes

Begin as ice crystals, which have a hexagonal lattice structure

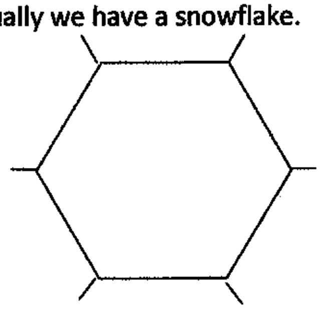


*Vocabulary: a **hexagon** is a polygon that has 6 sides

*Hexagonal lattice:

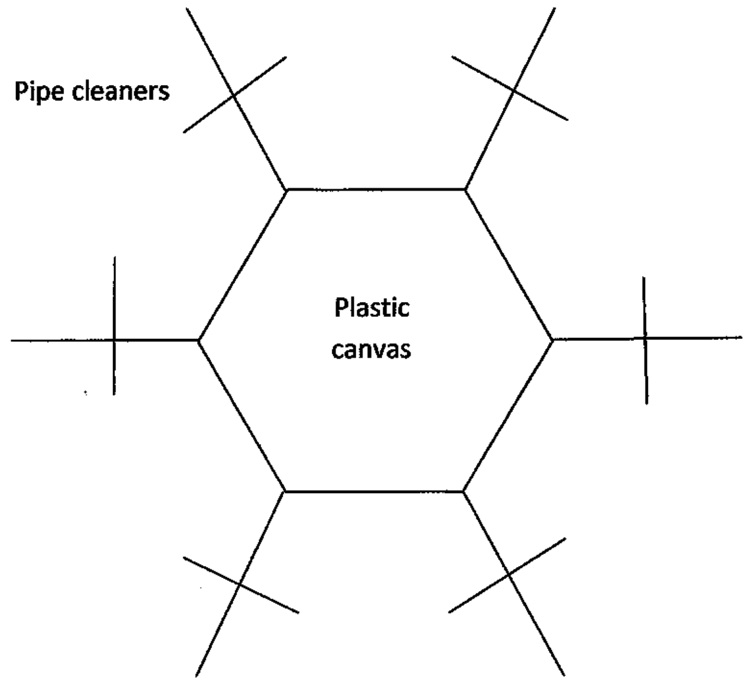


Water vapor begins to condense on these crystal structures and as the ice crystal grows larger, branches begin to develop from the corners of the hexagon, like this. These branches keep developing and eventually we have a snowflake.



Activity

Students will be in groups of 6 creating large snowflakes. Each group will have one plastic canvas hexagon. Each student will be in charge of creating one branch of the snowflake. The students will use pipe cleaners to design the branches of the snowflake. The goal for the students is to make the snowflake as symmetric as possible, so what one student does to their side, everyone working on that snowflake must do to theirs also. The pipe cleaners can be twisted together to form the branches, and can be connected to the hexagon to finalize the snowflake. This can be used as a contest to see which group can create the most symmetric snowflake, most creative, etc.



Summary

Questions:

How did creating your snowflake compare to the way snowflakes are formed naturally?

Are your snowflakes perfectly symmetrical? Why not?

How does this compare to natural snowflakes?

How easy would it be to make a snowflake look exactly like another groups?

Will two natural snowflakes ever be the same?

Activity: BEES

Objective: Students will gain knowledge on how symmetry affects nature, specifically bees and flowers. They will be able to identify the different types of symmetry in different flowers.

Materials: Pictures of different types of flowers

Review

Line (reflection) symmetry: a figure can be folded so that the parts match up exactly

Rotational symmetry: a figure coincides with the original figure after being rotate less than one full turn (360 degrees)

Bees:

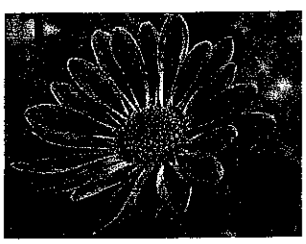
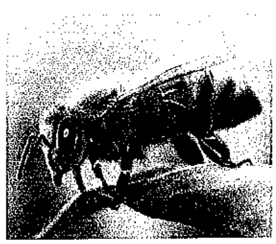
Color blind and can't judge distances

See as if looking through a thick pane of glass

Attracted to flowers based on symmetry of the flower, not color!

Different types of bees are attracted to different types of flowers

Honeybees: attracted to flowers with rotational symmetry

Bumblebees: attracted to flowers with line symmetry


Activity

Students will be in groups of two. With their partner, they will decide whether each flower has rotational or line symmetry, and consequently, which type of bee is attracted to it.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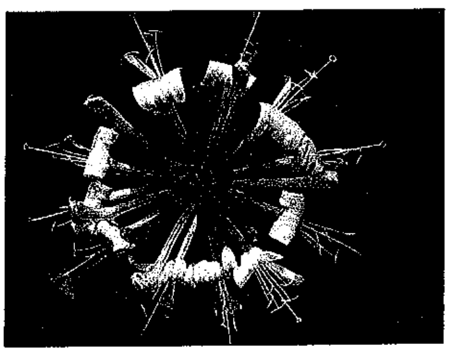
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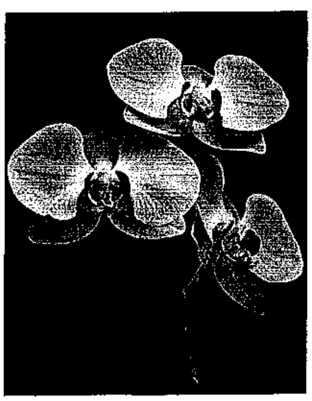
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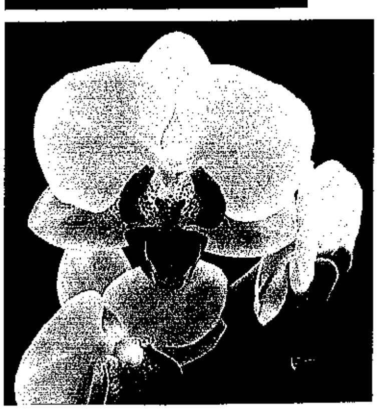
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8.

9. 

10. 

Summary

Questions:

What were some techniques you used to tell the difference between line and rotational symmetry?

Is it possible to have both line and rotational symmetry in one flower?

How did you decide which one to choose if it had both symmetries?

*If the technology allows, this activity could use a Smartboard with Senteo software (a program that allows students to click in their answers).

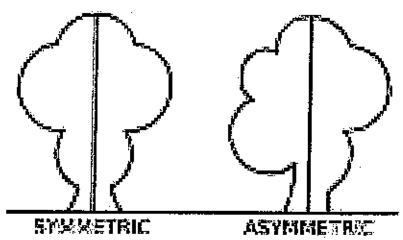
Activity: SYMMETRY AND BALANCE

Objective: Students will understand the importance of the role that symmetry plays in balance. They will see this through experimentation with asymmetry.

Materials: Spinning tops, tape, paper, high heeled (tall) shoes

Review

Asymmetry: an object has no symmetry



Activity

Students will go through two stages with a partner. In one stage, they will have a spinning top. The students will spin the top a few times normally. Then, they will tape a balled up piece of paper on one side of the top, and spin it again. They will compare the two ways of spinning the top and record their observations. In the next stage, students will wear a high heeled shoe, or taller shoe than they are already wearing on one foot. They will have to walk up and down the hallway, jog, balance on one foot and again, record their observations.

Summary

Discussion questions:

Was the top symmetrical after you taped something on the side? What do we call it if it's not symmetrical?

How was the spinning of the top affected by being asymmetrical?

How were you affected when you had one taller shoe on? Do you think it would make you slower or faster?

How does symmetry affect your balance? Do you think it affects the balance of other things in the same way?

Why is it important for animals to be symmetrical?

Activity: 3-D Symmetry

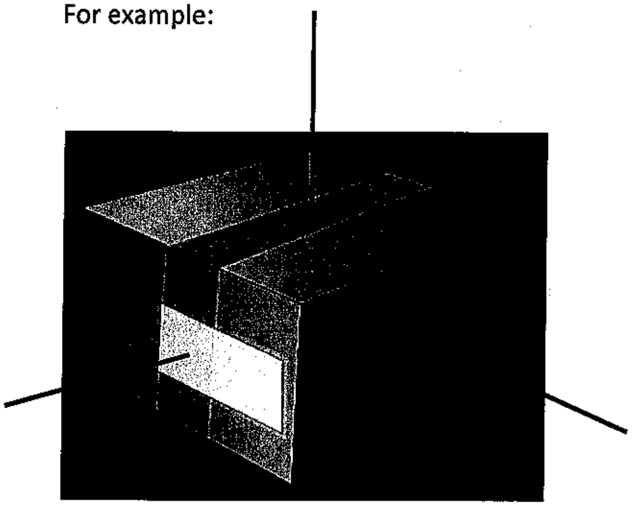
Objective: Students will be introduced to symmetry in 3 dimensions by working hands on with it. They will work with examples to identify the axes of symmetry in 3 dimensional objects.

Introduction

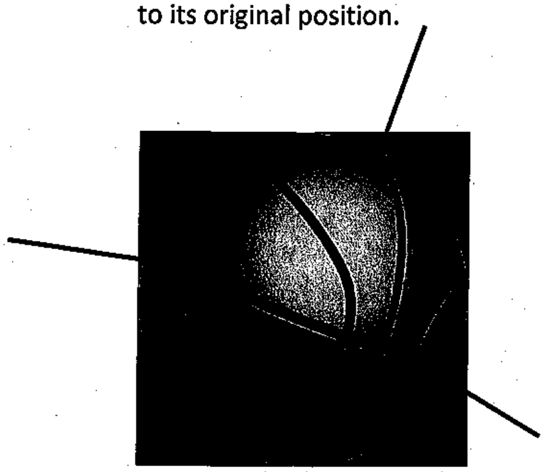
When we look at 3 dimensional objects, we can find axes of symmetry that they contain.

The object has rotational symmetry around this axis of symmetry.

For example:



This box has 3 different axes of symmetry. On each axis, the box can be rotated twice before it returns to its original position.

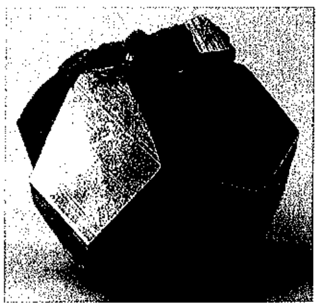


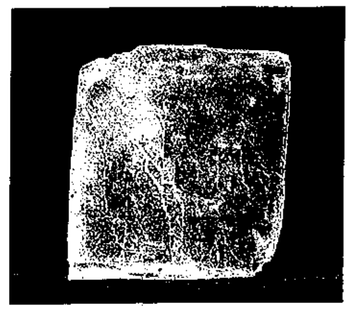
This basketball also has 3 different axes of symmetry. Again, the ball can be rotated twice around each axis before it returns to its original position.

Activity

In groups of 2 or 3, students will be given bamboo skewers, and an orange (the orange will have lines drawn on the outside to represent the slices). The students will place a skewer through the different lines of symmetry in the orange, seeing how many they can find.

Additional items, such as a dodecahedron to represent the mineral pyrite or a cube to represent salt crystals can be used.





Summary

How many lines of symmetry did you find in each object?

How many times can the object be rotated around each axis?

Which axes were the most obvious?

Which axes were the hardest to find?

What are some other objects in nature that we could do this with?