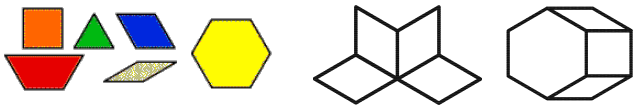


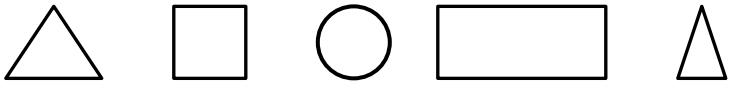
ABOUT THE MATH IN PATTERN BLOCK PUZZLES

If you watch and listen to how students interact with the pattern blocks, you can learn a lot about what they know and what they are ready to learn. Once you see what they can do, you can help them take the next step in their learning. In this game, children practice:

- Knowing names of familiar shapes
- Describing and comparing attributes of shapes using age-appropriate geometric language (corners/angles, sides, length, same/equal, more/less, shorter/longer)
- Composing (putting together) and decomposing (taking apart) shapes
- Thinking flexibly and logically about shape

This section discusses some of the mathematical skills that children are building as they play with the pattern block puzzles. In mathematics, just as in their language and social/emotional skills, preschool children vary greatly in what they know and are able to do depending on their development and the experiences they've had. Students in the U.S. are typically weaker in their geometry skills than children in other countries, even in preschool. Fortunately, children enjoy playing with and talking about shapes and the more practice and exposure they have, the more they will learn.

Naming Shapes. Knowing the name of a shape is just a small piece of knowing about that shape—like knowing the name of a person is knowing just a small amount about them. It is important that children look carefully at the properties or attributes of various shapes and learn to distinguish between them. Children construct ideas about shapes by manipulating them and using them in play. When introducing *abstract* shapes or drawings of shapes on paper, young children's books and toys tend to start with closed, symmetrical shapes such as equilateral or isosceles triangles, squares, circles, and rectangles. And these materials tend to present these shapes as they would sit on the table, not like  .



Regular shapes with horizontal bases are the shapes most commonly used in children's toys and the ones they are most likely to see or have pointed out to them. With familiar real-world objects, children recognize the outline (shape) even when it is tilted or completely upside down. With abstract shapes, children *may* think that the way it is rotated matters. For example, children who recognize  as a square may think that  is not a square. It is common, and perfectly fine, to call that second shape a "diamond," but it's important also for children to understand that it is still a square, just in a different orientation. This never happens with physical objects on a table, which children *know* can be dropped down in any position and can be repositioned, but children have no way of knowing whether the name of a shape *drawn*

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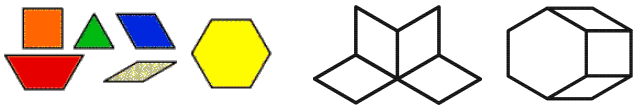


on paper depends on its orientation or not. After all, they will put great effort into learning that p, d and b have different names, even though they are *exactly* the same shape, just in three different orientations. Similarly, they will put great effort into learning that three is written 3, not ε; sometimes orientation matters a great deal. As a result, children may assume that, on paper, □ and ◇ may be different shapes. Children need to learn explicitly that when we ask "what *shape* is this?" orientation *doesn't* matter. Otherwise, the confusion that turning a shape will change its name can last into later elementary school. Providing children instruction focused on the shape's defining attributes—such as number and length of sides—helps them create more accurate understandings.

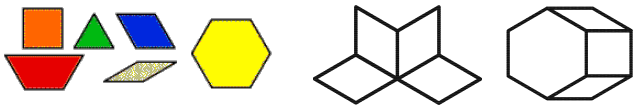
As children play with the pattern blocks, use geometric language naturally as it emerges. Name the shapes they are using and talk about the number of sides, corners/angles, and ask questions to get them to start noticing the defining characteristics of shapes like: *How do you know that shape is a square? Does it have 4 sides? Does it have 4 corners? Are the corners square (right angles) like the corners of this paper? Are all the sides the same length? If you turn a square is it still a square? What other shapes have 4 sides?*

One limitation of the pattern blocks is that they only provide exposure to six fixed shapes (one triangle, four quadrilaterals (square, trapezoid, two rhombuses), and a hexagon). Children need exposure to lots of different types of triangles and quadrilaterals and other shapes to develop a deeper understanding of their defining characteristics. Other materials and books can help fill this gap.

Shape Attributes. An attribute is broadly defined as a characteristic or quality belonging to a person, thing, or group. When talking to children about attributes it can be helpful to think of using our five senses to 'find' the attributes of things: *What does it look like (eyes)? Sound like (ears)? Smell like (nose)? Taste like (mouth)? Feel like (touch)?* All of our senses give us important information about the world around us. Developing children's ability to identify and define attributes is an important mathematical habit of mind.

In playing the pattern block games, we are primarily using our eyes and our touch to define the attributes of shapes. Children can see and feel the corners and straight lines that make up the shapes. While children naturally notice color or size first, those are not a defining attribute of what makes a triangle a triangle or a square a square. To be a square, a shape must have straight sides, four sides of equal length, four right (90 degree) angles or corners. The triangle and quadrilateral Venn diagrams (pages 7 & 8) organize these shapes by their defining attributes and is a helpful reference for you to think about comparing shapes. It is not a reference for the children—children are not expected to see all the relationships between these shapes until middle school or later.

As children are working to name, identify, and match shapes, introduce language about shape as it comes up naturally. Talk about the number and length of sides, the number and size of angles/corners. Since precise angle measure cannot have meaning at this age—children don't know what 90 is, let alone 90 *degrees*—it is enough for them to notice whether angles *match* the corner of a sheet of paper "a right angle," or are "pointier" or "less than a right angle" or "wider" or "more than a right angle." You can even talk about whether the sides are



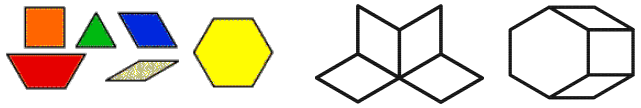
parallel or not using the analogy of train tracks to define parallel lines, or by thinking of the lines "going in the same direction." We want to increase the language and vocabulary children have to clearly and precisely describe shapes (and by extension, the world around them). If they draw letters, we can talk about them with the same language. An H has two parallel lines. An E has *three* parallel lines! The rectangle, square and rhombus often cause confusion, even for adults. Spend a few minutes looking at the attributes of these shapes and helping children distinguish what features the shape *must* have from the features that it *may* have. A rhombus *must* have four equal sides. It *may* have right angles, but it doesn't have to. A square has four equal sides (so it is a rhombus), and it *must* have right angles (so it is a very special rhombus). A rectangle *must* have four sides and four right angles. It *may* have all sides the same length, but the opposite sides must have the same length. A square has four sides and four right angles (so it is a rectangle), and it *must* have all its sides the same length (so it is a very special rectangle). We want to increase the language and vocabulary children have to clearly and precisely describe shapes (and by extension, the world around them).

Composition and Decomposition of Shapes. Putting together and taking apart shapes in an important skill on its own, but also as it relates to later mathematics such as part-whole relationships, fractions, area, volume, as well as engineering and design. The pattern blocks, for example, are often used in later grades to teach fractions (e.g. two trapezoids make one hexagon; three blue rhombuses make one hexagon; and three triangles make one hexagon). Early explorations with how these shapes can be put together and taken apart helps children see the world as made up of shapes and prepares them for later mathematical ideas.

The simple geometric puzzles are a good place to begin to see if children are manipulating the pattern blocks as individual shapes or ready to combine them to make more complex pictures. The animal puzzles are scaffolded so that the youngest children can use the color to help them place the shapes, then use the puzzle with all the shapes outlined, then use the puzzle with just the outside outlined. The puzzles that ask children to find how many ways to make the triangle, star, parallelogram, or hexagon are designed to push their thinking about how to put together and take apart shapes. They may recognize they can build the trapezoid in several different ways by using one blue rhombus and one triangle, or using three triangles.

The pattern blocks are designed to fit together well. All the sides are equal in length or double the length (the long edge of the trapezoid), and the angles fit together (they are all multiples of 30 degrees). Composing two triangles makes a blue rhombus, a rhombus and triangle make a trapezoid, etc.

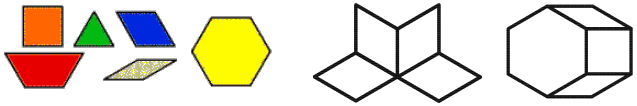
Address Equity. Pay particular attention to spatial thinking in girls because they may have had fewer previous experiences with block building and other spatial toys. Spatial reasoning is a predictor of later mathematics achievement; notice whether *all* children in your room are having these early experiences.



Progression of Geometry and Pattern Concepts from 3- to 6-Years-Old (End of Kindergarten)

The lines between columns are intentionally fuzzy because the age is approximate. This progression is not to be used as an assessment or checklist, or to judge whether a child is ready to transition to Kindergarten. They represent expectations for children, but each child will reach these indicators at their own pace and their own way. These are meant to help you know what to expect; what learning may come first and what learning may come next for most children.

	@3 years old	@4 years old	@5 years old	@6 years old (end of Kindergarten)
Naming Shapes	Names typical 2D shapes (circles, squares, triangles, rectangles)	Names and describes familiar 2D shapes (circle, square, triangle, rectangle). Begins to recognize less typical examples (i.e. long skinny triangle still a triangle because it has 3 sides)	Names and describes most 2D shapes regardless of orientation and size (e.g., familiar shapes plus rhombuses, trapezoids, hexagons)	Correctly names and describes 2D shapes regardless of orientation or size (e.g. familiar shapes plus more such as octagons, parallelograms, convex/concave figures)
Shape Attributes	Notices shapes have sides and corners	Begins to describe shapes by number of sides and corners and sides of same or different length	Describes shapes by number of sides and corners and sides of same or different length	Describes and compares shape similarities, differences, and parts using language such as number of sides and corners, and sides of same or different length
Composing and Decompos-ing Shapes	Manipulates shapes individually, but does not combine them to make larger shape	Fills in outline pictures that show where each shape goes using trial and error	Fills blank outline puzzles intentionally selecting and placing shapes (rotating and flipping as needed)	Composes simple shapes to form larger shapes (e.g. join 2 trapezoids to make a hexagon)



Triangles

(closed figure with three straight sides)

Isosceles
(two sides the same length)

Equilateral
(All three sides the same length and all three angles the same size (60 degrees))

Right
(one right angle (90 degrees))

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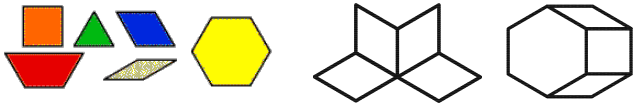
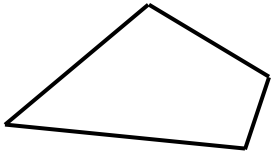
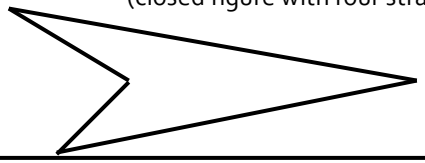
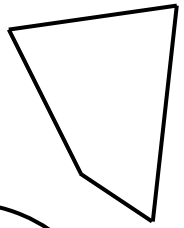


Quadrilaterals

(closed figure with four straight sides)

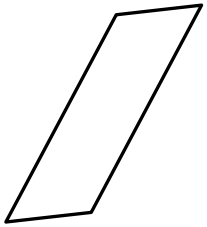


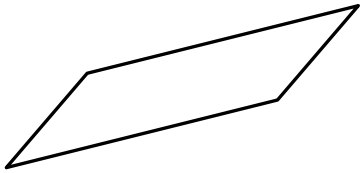




Parallelograms

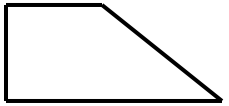
(opposite sides the same length and parallel)





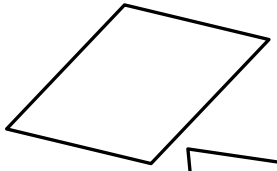
Trapezoids

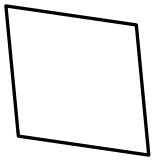
(at least one pair of parallel sides)



Rhombuses

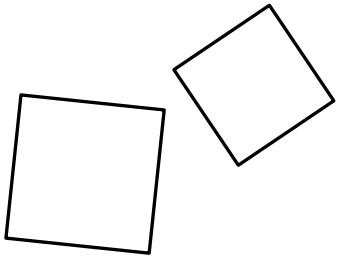
(sides all the same length)





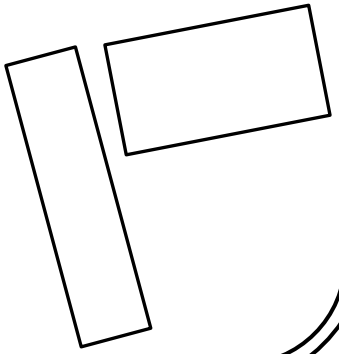
Squares

(All four sides the same length and parallel AND four right angles)



Rectangle

(opposite sides the same length and parallel AND four right angles)



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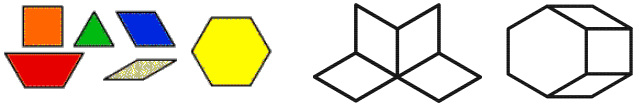
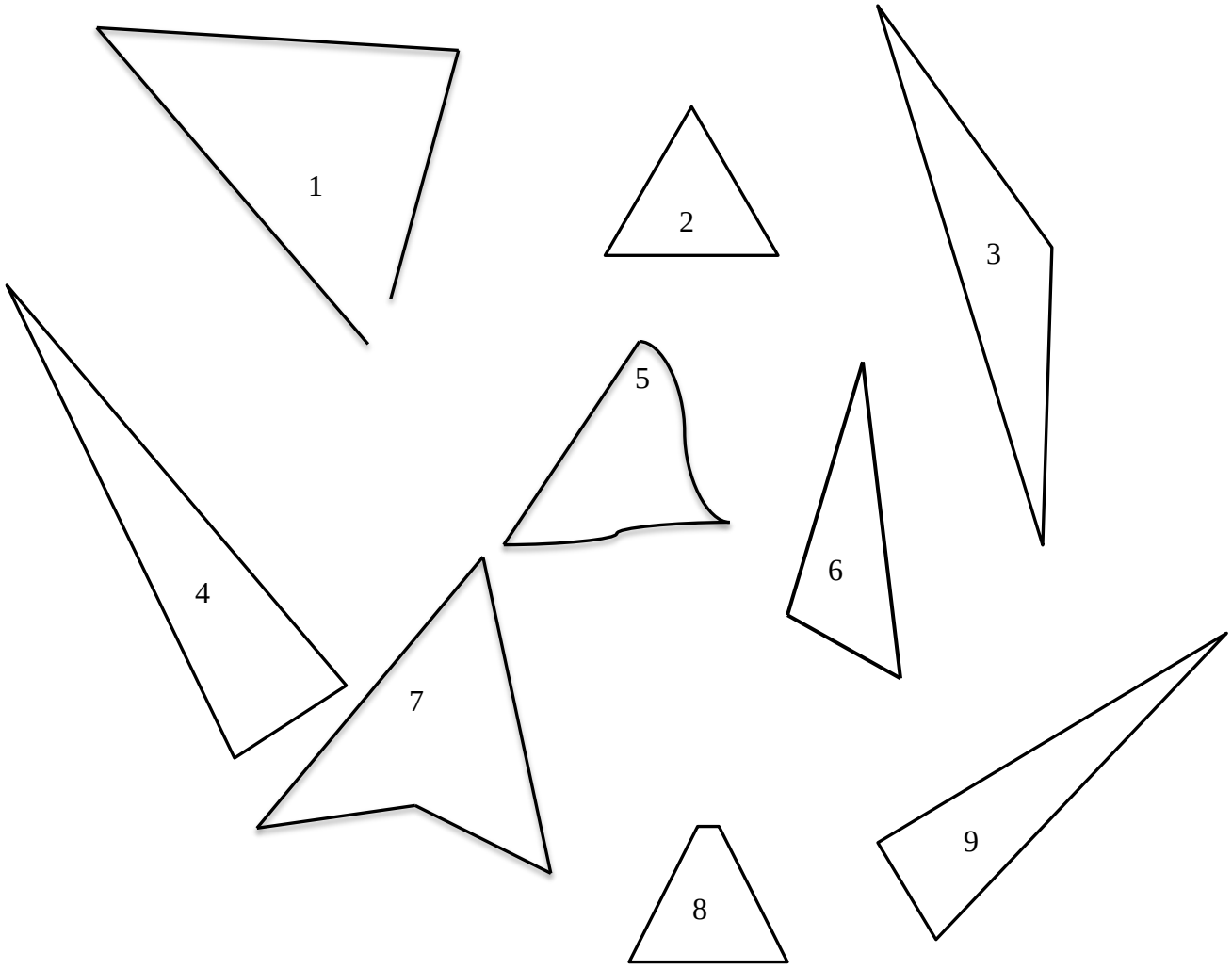


Find the Triangles



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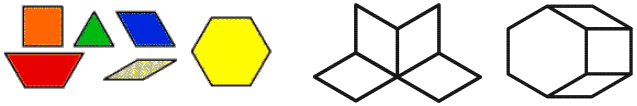
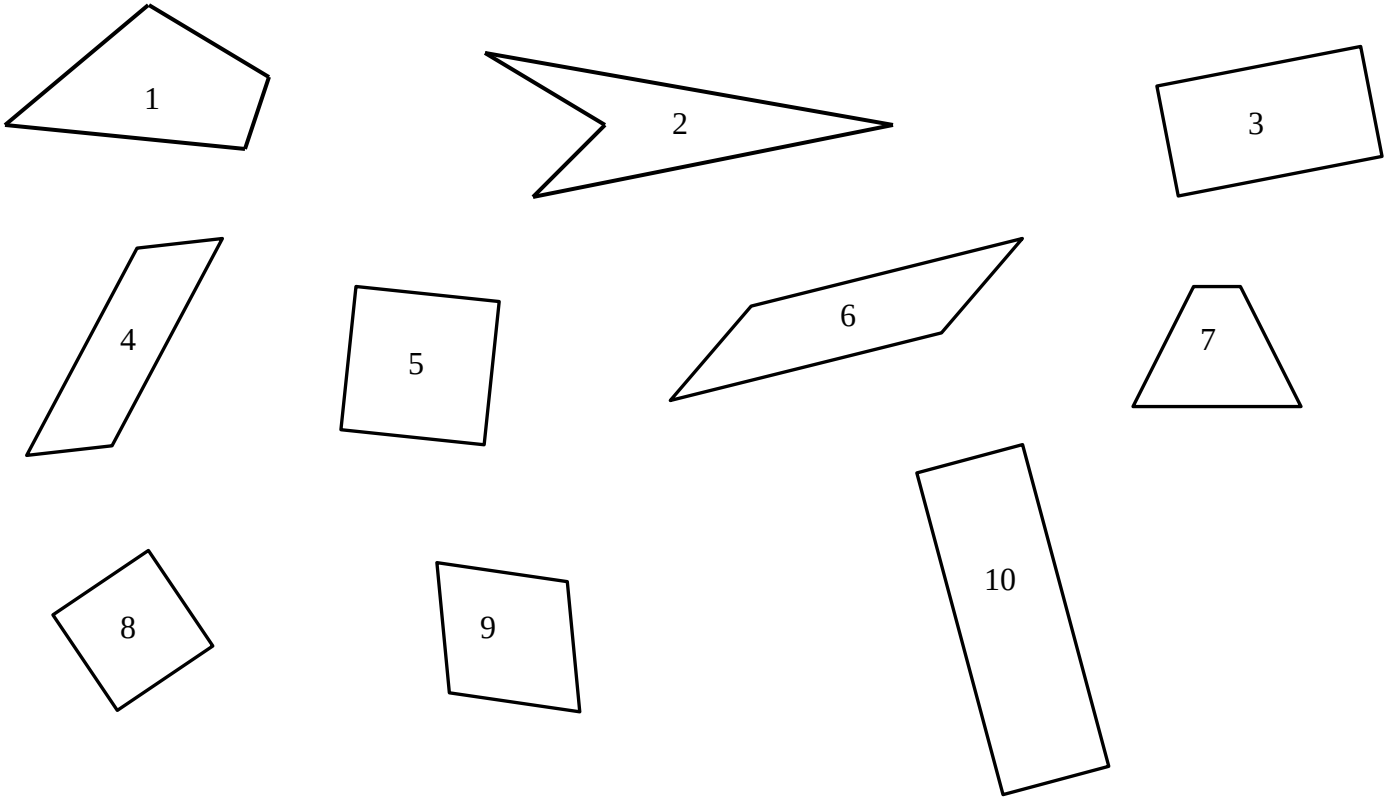


Find the Rectangles



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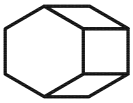
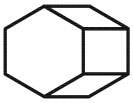


Geometric Terms[1]

Term	Meaning
Angle	The shape formed by two lines that meet at a point. That point is called the vertex of the angle; the lines are called the sides of the angle. A right angle matches the corner of a sheet of paper. When we measure in degrees (unimportant at this age), its measure is 90 degrees.
Closed figure	A figure is called "closed" when it separates an inside from an outside and one cannot get from the inside to the outside without crossing a line. A circle is a closed figure. A triangle is a closed figure. The letter U is an open figure: one can get from the "inside" to the "outside" without crossing the line.
Mirror Symmetry	A shape has mirror symmetry if the shape can be folded in such a way that the two parts lie precisely on top of each other, matching exactly. A rectangle can be folded side-to-side, splitting the other two sides in half, and the two parts will match exactly. That fold is called the *line of symmetry*. If you fold a rectangle (that isn't a square) along its diagonal, the two parts are the same size and shape, but don't lie perfectly on each other matching exactly. That fold line is *not* a line of symmetry, but because the rectangle has *other* lines of symmetry, we say it has mirror symmetry.
Orientation	How a figure is turned compared to a reference line.
Parallel	Lines have the same orientation and remain the same distance apart (like railroad tracks).
Polygon	A closed 2D figure with three or more straight sides.
Rotational symmetry	A figure has rotational symmetry if it can be turned less than a full turn and fit on itself exactly. A square, for example, can be rotated one fourth of the way around (90°) and fit on itself exactly.
Concave	At least one corner looks caved in; an interior angle of the polygon is greater than 180 degrees.  and  are six-sided concave polygons.
Convex	Every interior angle is less than 180 degrees; no corner pokes into the figure.  is a five-sided convex polygon.

[1] Children may find these terms interesting but there is no expectation that they learn them.





Polygon Names

Triangle	3 straight sides
Quadrilateral	4 straight sides
Pentagon	5 straight sides
Hexagon	6 straight sides
Septagon	7 straight sides
Octagon	8 straight sides

OBSERVATIONS TO MAKE WHILE PLAYING

As you observe what your children are doing, support them to take the next step in their mathematical thinking by modeling, questioning, and explaining.

Do children		*Do children*
• Focus on number of sides and corners when identifying a shape?	OR	• Focus on how similar a shape looks to a familiar shape?
• Recognize shapes even if the position is "upside down" or unfamiliar?	OR	• Correctly identify only shapes that are in a more "typical" position?
• Fit the blocks into the puzzle?	OR	• Lay the blocks inside the puzzle whether or not they fit?
• Pay attention to the boundaries?	OR	• Let the blocks go over the lines?
• Test the blocks or move them around to make them fit?	OR	• Put any block in whether or not it fits?
• Move shapes using rotating and flipping to combine shapes to make a picture	OR	• Uses trial and error to fill in shape puzzles
• Know ahead of time what blocks to get?	OR	• Try out blocks to see what happens?
• Find more than one way to solve the outline puzzles?	OR	• Only solve the outline puzzles in one way?

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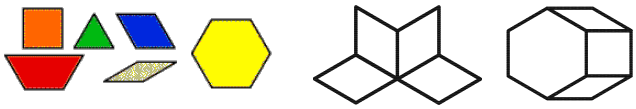


BOOK LINKS

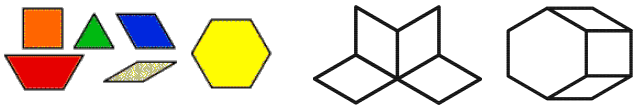
Mouse Shapes by Ellen Stoll Walsh
In this book, the mice hide from a cat in a pile of shapes. They have fun making things with the shapes—but the cat finds them! They decide to use the shapes to build "three big scary mice" to scare the cat—and it works! After reading this book, your children could use paper and cut out shapes to build their own designs—a great way to get them thinking about how geometric shapes fit together and make pictures.

Color Zoo *by Lois Ehlert*
This unique book has artfully cut out and overlaid pages that use shapes—rectangles, squares, circles, triangles, ovals, and more—to make the faces of animals. The bright, colorful designs are ones that will keep the children coming back to look again and again. You can extend this to an art activity by having children glue together different shapes—rectangles, squares, hearts, ovals, triangles, rhombuses, and more—to make creations of their own design.

Bear in a Square, Oso en un cuadrado by Stella Blackstone
Shapes, counting, rhyming, bilingual Spanish and English—this book has it all. On each page bear is looking for a different shape—squares, hearts, circles, rectangles, triangles, rhombuses, zigzags, ovals, and stars. He has to find a certain number, 1-10 of each one. The total number of shapes on the page are shown on the sidebar on the right hand side of the page. The simple, rhyming text is in English and Spanish so children can learn the shape names in both languages. You can extend this book into an art activity by having children glue shapes onto their paper and create a picture around them.

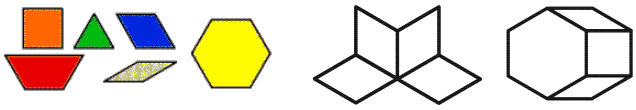
What is Square? *by Rebecca Kai Dotlich*
The text is simple and rhymes with lots of examples of things in the world that are square. A great basic book that can inspire children to go on their own shape hunt or make a collection of objects that are all square.

Shapes (Math Counts) by Henry Pluckrose
A great book to get children thinking about the shapes they see in the world around them. The first few pages ask children to run their finger around the edge of a square, circle, rectangle, hexagon, and triangle. Then there is a page showing three different squares and the next page showing five different triangles that ask children to look at how they are similar and different. The next part of the book is great for talking about going on a shape hunt---there are photographs where children can find rectangles, squares, triangles, circles in the real world—even hexagons in the honeycomb. On page 16, the author introduces the word *tessellation* to describe shapes that fit together without leaving spaces. While the word is probably new to children, its probably a concept they have experienced when building in the block area or making designs with the pattern blocks.



You can use this book as an inspiration to go on a shape hunt in your classroom, your school, and outside. Find circles such as clocks, knobs, or stools. Find rectangles in windows, art paper, or photographs. Have children cut out their own shapes and glue them onto paper to make pictures and designs.

So Many Circles, So Many Squares by Tana Hoban
In this wordless picture book, Tana Hoban has taken colorful photographs of images from everyday life with circles and squares. Children will enjoy hunting for the shapes in these pictures and it is a great jumping off point for going on a shape hunt. Note that some of the "squares" have rounded corners and some of the examples of circles, like onions and grapes aren't really circles.



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