# What am I?

## A Game Connecting Mathematics and the Environment

by John Mighton, Founder of JUMP Math


Teacher's Guide: Junior level

### **Lesson 1:** *Classification in Geometry*

#### Introduction

Mathematicians and biologists study very different things. Mathematicians study numbers, patterns, and shapes, while biologists study plants and animals. However mathematicians and biologists both need to know how to sort and classify things, because it helps them understand how the things they study are related and how they work and are put together. And numbers, patterns, and shapes are present everywhere in nature, even in living things. So when you study the natural world, you end up using and discovering a great deal of mathematics.

Tell your students that in the next three lessons they will play a game called "What am I?". In this game, they must act like detectives and try to find answers to various problems by asking the least number of questions possible. By playing the game, students will see how sorting and classifying things in a clever way can help them ask useful questions when they are trying to solve a puzzle or a mystery. They will also see how mathematics is present everywhere in nature, and they will learn (in Lesson 3) how they can use their knowledge to help protect the environment.

#### Preparation

Place a selection of the shape cards from Blackline Master (BLM) 1: Shape Sorting Game (Junior) on the board and ask students to discuss what properties they might use to sort the shapes. You might have students work in groups, each with a set of shape cards. You might also provide them with rulers (to measure the sides of the shapes) or protractors (to measure the angles of the shapes) and you might also encourage them to fold the shapes to see whether they have any lines of symmetry.

When students think about how they would sort the shapes, they might consider the following types of questions:

How many corners (or vertices) does the shape have?
How many sides does the shape have?
Are the sides all straight or are some sides curved?
Does the shape have any square corners (right angles)? If so, how many?
Does the shape have any lines of symmetry?
Is the shape equilateral (that is, are all sides of the same length)?
Does the shape have any pairs of parallel sides?
Does the shape have a special name?

If your students are not able to describe the shapes using geometric terms, you might review the following terms:

The **sides** of a shape are the lines that form the boundary of the shape.

A **vertex** is a point where two sides of a figure meet.

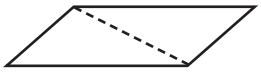
A **square corner** or **right angle** is an angle of the type found at the corner of a square (and is also called a 90 degree angle).

A shape is **equilateral** if all of its sides are of the same length.

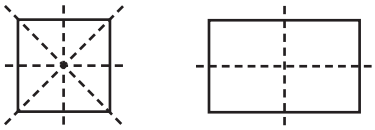
  

A **line of symmetry** is a line that divides a shape into two matching parts. To test whether a line is a line of symmetry, fold the shape along the line. If the two parts of the shape on either side of the line do not match up exactly, the line is not a line of symmetry.

The line shown in the diagram below is not a line of symmetry: even though the two parts of the figure are the same shape and size, they do not match up when the figure is folded along the line.



A square has four lines of symmetry but a rectangle has only two.



Lines are **parallel** if they are straight and if they would never meet when extended.

A shape with three straight sides is a **triangle**, four sides a **quadrilateral**, five sides a **pentagon**, six sides a **hexagon**, and eight sides an **octagon**.

Some quadrilaterals have special names. A **square** has four equal sides and four right angles. A **rectangle** has opposite sides that are equal and four right angles. A **rhombus** has four equal sides but not necessarily any right angles. Shape R is a rhombus, and so is shape F — a square. In a **parallelogram** opposite sides are parallel and of equal length. A square, rectangle, and rhombus are all parallelograms, as is shape I. A **trapezoid**, such as shapes J and Q, has exactly one pair of parallel sides. Figure K is a **dart** and figure L is a **kite**.

## The Shape Game


Cut out shapes A, B, C, D, E, F, G and H on the blackline master BLM 1: 2-D Shape Sorting Game (Junior) and post them on the board using sticky-tack or tape. Tell your students that you are thinking about one of the shapes. They must find out what shape you are thinking of by asking you questions, to which you will only answer "Yes" or "No." The goal of the game is to identify the shape by asking the least number of questions. (You might let one student at a time ask questions until they have found the answer, or you might allow students to take turns asking questions). Students are not allowed to say the letter printed on the shape: they must identify the shape using geometric terms.

Play the game several times, keeping track of how many questions your students have to ask each time. Students should see that if they start by asking questions that are very specific, such as "Are you thinking of a square?", they may have to ask many questions before they learn the answer. (As there are eight shapes, they might need to ask as many as seven questions this way).

Ask your students whether they have a strategy for playing the game. Can they always find the answer by asking a certain number of questions? Students should see that they only need to ask three questions. The first question, for instance, might tell them the number of sides or vertices ("Does the shape have three sides?"), the second the type of sides ("Does the shape have any curved sides?"), the third the exact shape (if the shape has curved sides the students might ask, "Does the shape have one or two curved sides?", and if the shape has all straight sides the student might ask, "Is the shape equilateral?"). Ask your students whether they would be certain to get the answer in three questions if they just guessed the shape at random. (No, it might take seven questions).

As students eliminate shapes by asking questions, you might remove the shapes from the board to make it easier for students to focus on the remaining shapes. You might also ask students to help you identify the shapes that have been eliminated by a particular question.

Below is a series of games of increasing difficulty that can be played with the geometric shapes on BLM 1. You should pick the games that suit your students. Post the shapes in each game on the board and play the game exactly as you played the previous game. You might allow students to come to the board and lead the game by picking a selection of shapes and asking their fellow students to guess the shape they are thinking of.

Research in psychology has shown that students' brains work far more efficiently if they are confident and engaged. One way to build confidence is to "raise the bar" incrementally by asking students a series of questions that appear to be harder and harder but that do not require any new skills or knowledge to answer. Make a big deal of your students' successes as you play the games.

There are many ways to sort the shapes in the games below, but in each game it is possible to identify any shape by asking just two or three questions. For each game, there are some suggested sorting attributes that students might use to sort the shapes.

## Game 1

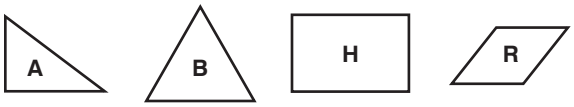
**Shapes**: A, B, F, H, T, U
**Sorting Attributes:** Students might sort the shapes according to the following attributes: 3 sides/4 sides/5 sides or 3 vertices/4 vertices/5 vertices or triangle/square/pentagon; then equilateral/not equilateral.

## Game 2

**Shapes:** A, B, O, P, W, X
**Sorting Attributes:** 3 sides/6 sides/8 sides or 3 vertices/6 vertices/8 vertices or triangle/hexagon/octagon; equilateral/not equilateral

## Game 3

**Shapes**: A, B, H, R




**Sorting Attributes:** equilateral/not equilateral; at least one square corner/no square corners

## Game 4

**Shapes:** A, B, N, X
**Sorting Attributes:** 3 sides/6 sides or triangle/hexagon; at least one line of symmetry/no line of symmetry or at least one square corner/no square corners

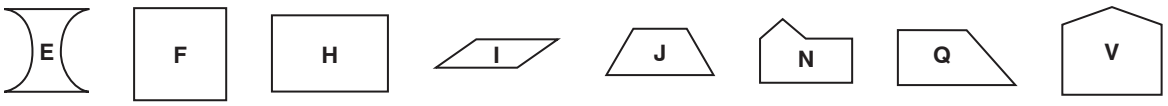
## Game 5

**Shapes**: H, P, S, U, V, X
**Sorting Attributes**: Shapes H, P, and X have two lines of symmetry, while shapes S, U, and V have one line of symmetry. (Alternatively, shapes H, P, and X have an even number of sides, while shapes S, U, and V have an odd number of sides.) The shapes can then be sorted by the number of sides and by whether they have square corners or not.

## Game 6

**Shapes**: E, F, H, I, J, N, Q, V



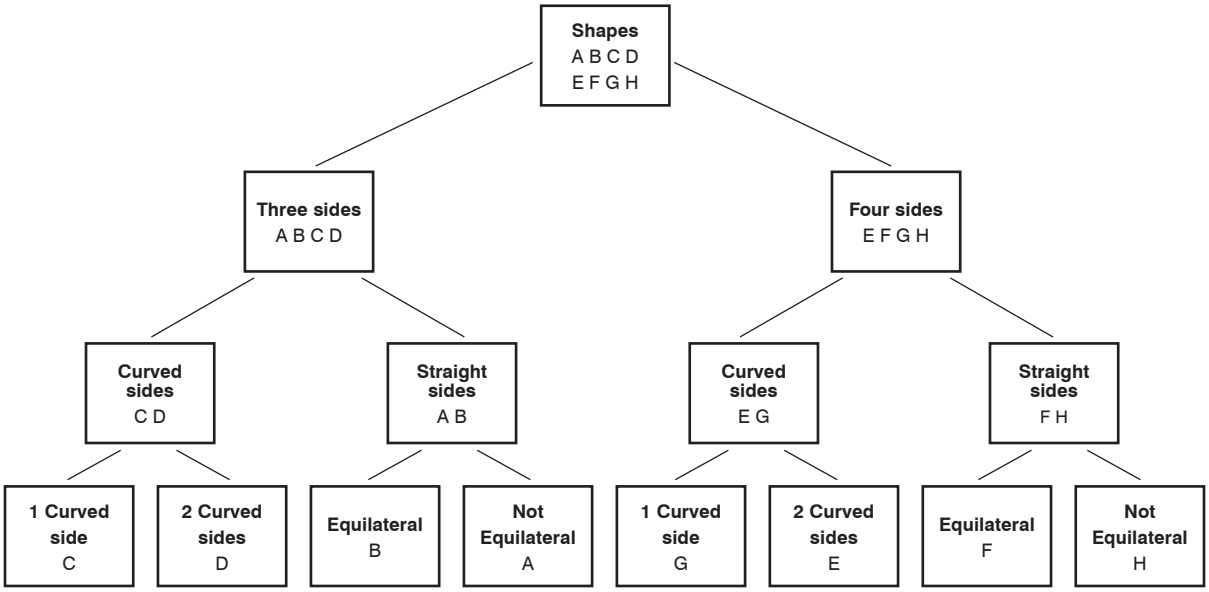

**Sorting Attributes**: Shapes E, J, Q, and V have one pair of parallel sides, while shapes F, H, I, and N have two pairs. Shapes E, J, Q, and V can then be sorted into two groups according to whether they have a square corner or not. Those two groups can be further sorted by the number of sides or the type of sides. Shapes F, H, I, and N can be sorted into two groups according to whether they have a line of symmetry or not. Those two groups can be further sorted by the number of sides or the type of figure.

## Game 7

**Shapes**: F, H, I, J, K, L, Q, R (all quadrilaterals)
**Sorting Attributes**: Students could use a number of attributes to sort the shapes, including number of square corners, lines of symmetry, and pairs of parallel sides, whether the shape has opposite sides or adjacent sides of the same length, and so on.

**Note**: If you have a younger junior class and you would like a selection of easier games, see the Primary version of this lesson plan. For more challenging games, see the Intermediate version. Also, you might put a random selection of shapes on the board and ask students to determine the minimum number of questions required to identify a shape.

For a bonus activity, you might ask your students to draw a **tree diagram** to show how they would classify a particular set of shapes. An example of what a tree diagram for Game 6 might look like is provided below. (As a warm-up, start with only four shapes.)




**Note:** JUMP Math is a charity dedicated to supporting teachers in the teaching of mathematics. JUMP has developed books and teacher's guides covering the curriculum from grades 1 to 8. JUMP also provides professional development for teachers. See the website www.jumpmath.org for details. JUMP would like to thank the artist Roger Hall (www.wildlife-artworks.com) for donating the use of his animal illustrations for these lessons.