# What am I?

## A Game Connecting Mathematics and the Environment

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Teacher's Guide: Intermediate 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. But 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 good 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: 2-D Shape Sorting Game (Intermediate) 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 give them 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 sorts 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? If so, how many?
Does the shape have a special name?
What kind of angles does the shape have (acute, obtuse, reflex)?

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.

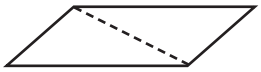
A **square corner** or **right angle** is an angle of the type found at the corner of a square (and is also called a 90 degree angle).

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

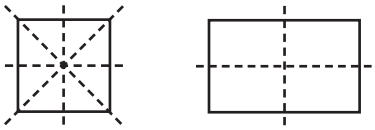
  

A **line of symmetry** is a line that divides a shape into two matching parts. To test whether a line is a line of symmetry, fold the shape along the line. If the two parts of the shape on either side of the line do not match up exactly, the line is not a line of symmetry.

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.

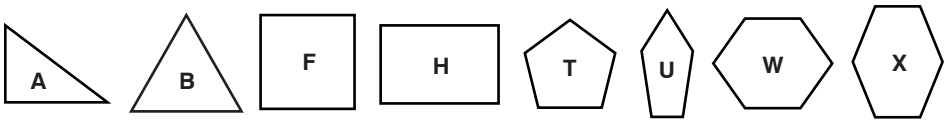
An angle is called **acute** if it is less than 90 degrees, **obtuse** if it is between 90 and 180 degrees, and **reflex** if it is between 180 and 360 degrees. Shapes E, G, K, M, and N all have one reflex angle.

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 triangles have special names. A triangle is called **equilateral** if it has all equal sides, **isosceles** if it has two equal sides, and **right angle** if it has a right angle. Any shape, including a triangle, is called **scalene** if all sides are of different lengths. Shapes C and D are scalene.

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, F, H, T, U, W, and X from the BLM 1 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, but 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 if they are clever they only need to ask three

questions. The first question, for instance, might tell them whether the shape is equilateral or not, the second whether the shape has more than four sides, and the third the exact number of sides. Alternatively, students might first ask whether the shape has at least one square corner, and then, if the answer is yes, whether the shape has four sides, and then, if the answer is no, whether the shape has six sides. (One more question would be needed to identify the exact shape). 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, O, P, W, X
**Sorting Attributes**: 3 sides/6 sides/8 sides or 3 vertices/6 vertices/8 vertices or triangle/hexagon/octagon; then equilateral/non-equilateral

## Game 2

**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 3

**Shapes**: C, D, H, S
**Sorting Attributes**: 3 sides/4 sides or triangle/quadrilateral; scalene/not scalene

## Game 4

**Shapes**: G, J, K, M, T, X
**Sorting Attributes**: 4 sides/5 sides/6 sides; reflex angle/no reflex angle

## Game 5

**Shapes**: E, G, M, N
**Sorting Attributes**: 5 sides/6 sides or pentagon/hexagon; 2 right angles/3 right angles

## Game 6

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

**Sorting Attributes**: Shapes J, M, Q, and V all have one pair of parallel sides, while shapes H, I, N, and F have two pairs. Shapes J, M, Q, and V can then be sorted into two groups according to the number of sides (J and Q have 4 sides and V and M have 5 sides). Q has 2 square corners and J has none. M has a reflex angle and V has none. Shapes H, I, N, and F 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**: A, G, J, L, M, N, V, X
**Sorting Attributes**: Shapes A, J, L, and M all have two acute angles, while the other shapes have none. Two of the shapes in the group A, J, L, and M have the same number of sides (four sides) as do two in the other group (six sides). Students could ask a variety of questions to identify the final shape.

**Note**: If you have a younger intermediate class and you would like a selection of easier games, see the Junior version of this lesson plan. For a more challenging exercise, 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 the introductory game (above) might look like is provided below.