Mathematical Experiments with Polystar

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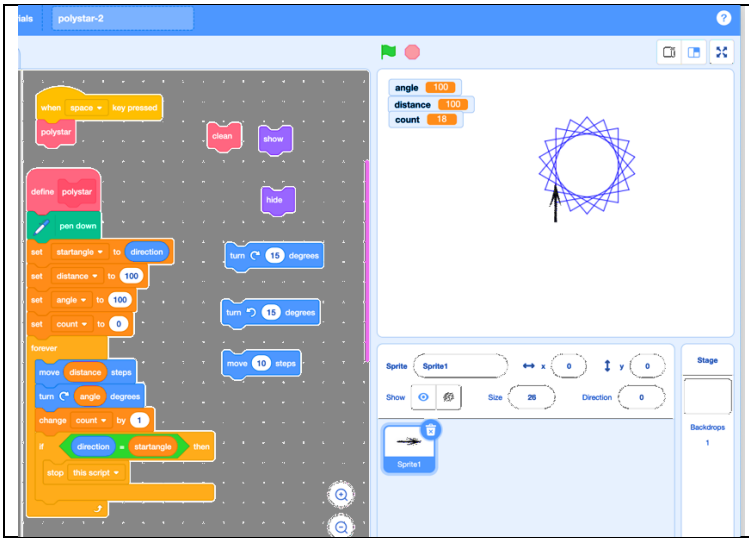
In this activity we will explore the behavior of a classic turtle geometry script, *Polystar*, to create geometric designs using two variables, *distance* and *angle*. The classic Logo "turtle" image is replaced by an arrow costume that represents the turtle.. The arrow rotates about its point, so you will always know the exact location and heading of the turtle.

You will find *Polystar* at https://scratch.mit.edu/studios/30090197 then find the project watt-polystar. You will need to scroll in the script window until you see the images below.

In addition to document you will want to print a copy of the *Polystar Experiments Record Sheet.*

To use *Polystar*, set values for the *angle* variable and the *distance* variable by entering numbers in for "Setangle" and "Setdistance" in the script window. To run the script, press the space bar.



SPACE BAR runs the script

CLEAN will clear the screen and recenter the turtle.

HIDE and SHOW will hide and show the turtle.

You can use and MOVE and TURN if you want to make designs using combinations of Polystar designs.

The stage window at the right in the figure above shows what happens for an *angle* of 100 and a *distance* of 100.

How do you think the shape might change if you increase or decrease the value of the *distance* variable by 10?

How do you think the shape might change if you increase or decrease the *angle* variable by 10?

Working with *Polystar* is about creating interesting designs and paying attention to the variables that are used to create them. Think of yourself as a scientist, investigating the behavior of a strange machine. Or as an artist, investigating the potential of a creative medium. Or as a mathematician investigating the relationship between geometric and numerical patterns.

Your task is to learn as much as you can about the behavior of the script: to understand the behavior of *Polystar* so that you can predict what the result will be for any value of angle and distance variables. You will need to describe the mechanical behavior of the script—what it makes the sprite do when *Polystar* runs – and the mathematical rules linking *Polystar's* variables to the resulting designs.

It's good to work in groups of 2 or 3 people at a computer. Then collaborate with other groups to combine and compare results. Make sure that each group includes a scribe or recorder.

RECORD YOUR RESULTS AND YOUR CONJECTURES ON THE POLYSTAR EXPERIMENT RECORD SHEETS (SEPARATE DOCUMENT).

The next few pages give some specific questions and challenges that you can use if you wish, to get started. You need not follow these in order. Just take any starting point and try what interests you.

Here are some starting points for *Polystar* explorations:

WARNING:

SOME VALUES OF THE VARIABLES WILL CAUSE THE SPRITE TO HIT THE EDGE OF THE SCREEN. WHEN THIS HAPPENS, JUST CLEAR THE SCREEN, MOVE THE SPRITE TO A GOOD STARTING PLACE AND START AGAIN. MAKE THE DISTANCE VARIABLE SMALLER IF NECESSARY.

1. Try *Polystar* with a variety of *angle* and *distance* variables. Keep records of the results. What type of designs does it make? Do any of the designs have names that you know? Can you invent names for unfamiliar designs?

2. What does the *angle* variable control? What does the distance variable control? Make a conjectures about this. Then invent some experiments to test your conjectures.

3. Expand the kinds of values you use for the variables. large numbers, small numbers, negative numbers, fractions, and decimals. Make predictions about what will happen.

4. Angle and distance are independent variables. They make the magic happen. However, to predict the results of a *polystar*, pay attention to the dependent variable count – which tells the number of vertices in the shape drawn by *polystar*. How many different values of distance and angle result in shapes with the same count?

5. One ultimate goal of this investigation is a game of “guess my rule”. What is the rule that determines the number of vertices (the count) in a polystar shape?

6. A few other leading questions: Can you make two designs that are symmetrical to each other? Can you create two different designs with the same number of vertices? Can you explain how this happens? Can you make exactly the same design with different sets of inputs.

7. The visual challenges on the following pages were intended as scaffolding for middle school students. Use some of them if this approach appeals to you.

8. As you work, write down any questions you have about *Polystar* or conjectures that you make. Devise experiments to try to answer the questions or test the conjectures.

9. As you work, record your data on the *Polystar* experiment record sheets.

Conclusions: Can you predict the type of shape and the number of points if you know the values of the *angle* and *distance* variables.

VISUAL CHALLENGES

1. Find the angle and distance variables to make each shape

A. angle ___
distance ___

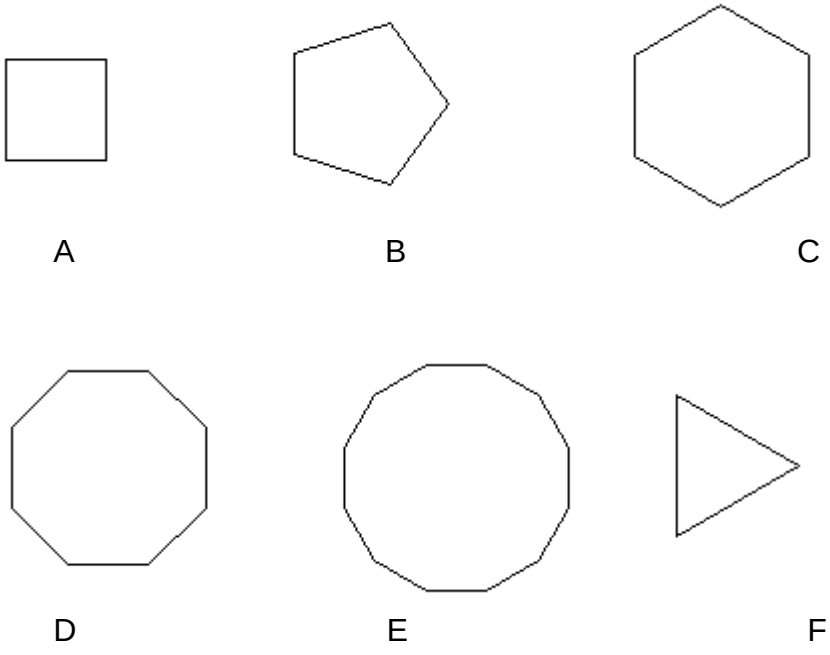
B. angle ____
distance ____

C. angle ____
distance ____

D. angle ___
distance ___

E. angle ____
distance ____

F. angle ____
distance ____



2. Find the variables needed to make each shape. Hint: the angle value is between 90 and 180

G. angle
distance

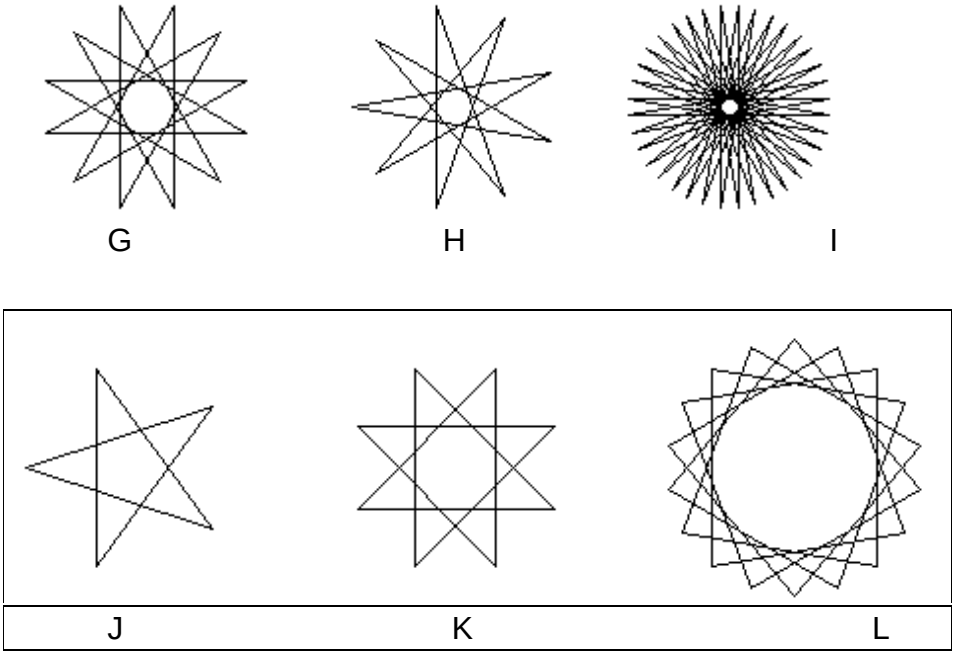
H. angle ____
distance ____

I. angle ____
distance ____

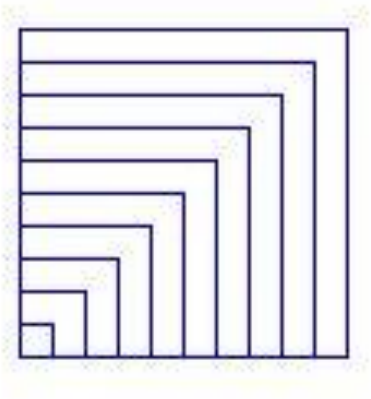
J. angle _____
distance ____

K. angle ____
distance ____

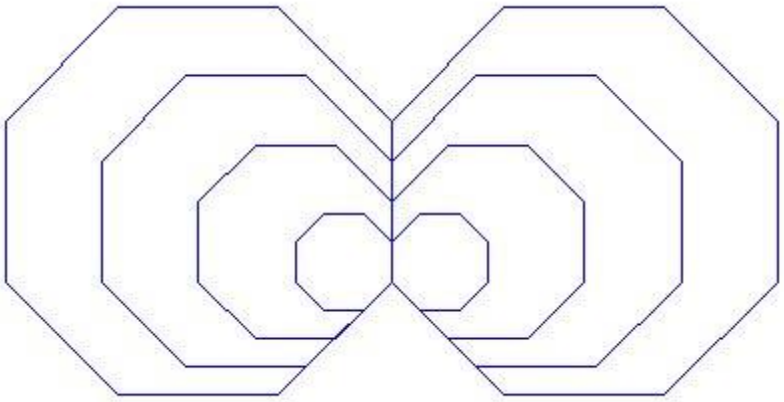
L. angle ____
distance ____



3. Find the variables needed to make this pattern of *Polystar* shapes.

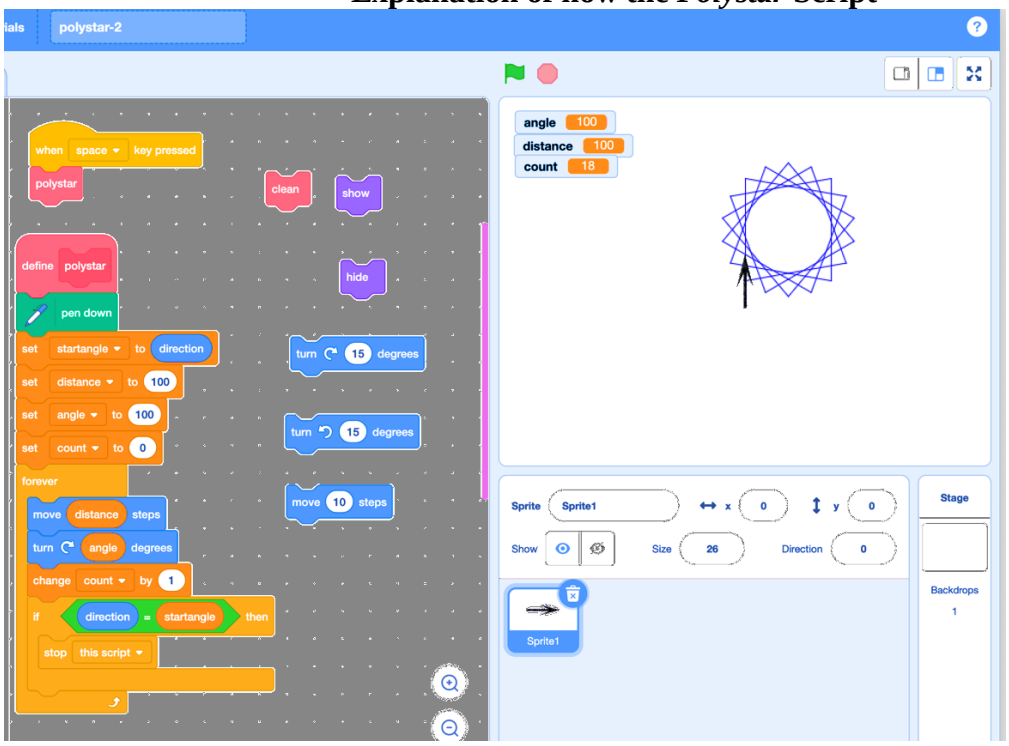


4. Find the inputs needed to make this pattern of *Polystar* shapes.



5. Make your own designs. Be sure to record the values of the *angle* and *distance* variables you use.

Explanation of how the *Polystar* Script



Polystar Design with *angle* 80, *distance* 100

Note: The Arrow sprite costume is chosen to show the turtle's position and direction of motion.

VARIABLES:

Startangle – this value is used to stop the program when the sprite returns to initial direction.

Count – this keeps track of the number of sides or vertices in the design

Angle – the turn variable

Distance – the move variable

STARTING BLOCK:
Sets *startangle* to the sprite's current direction (this allows for designs in different orientations;
Sets *count* to 0.
User enters values for *angle* and *distance*.

MAIN BLOCK
Moves and turns the sprite "forever" and increments count by one.

Until, *direction* = *startangle*, which stops the process.

SUGGESTION: Add a *wait* block to the main block to slow down the action so you can see what is happening. Set the *wait* value to 0 to make the action fast again.

Polystar Experiment Record Sheet

The headings below are for you to use to record your thinking during this investigation. They are in no particular order, and additional pages are available if you want to use them.

You can record your data on the next page. Make as many copies as you need.

Questions:

Conjectures:

Descriptions of Experiments:

Observations and Findings:

Which of the variables, the *angle* or the *distance* determines the number of points in a *Polystar* design? Make a chart like the following to collect your results.

Get as much data as you can for this chart. Collaborate and share data with other groups.

Angle variable	Distance variable	Number of points	Polygon or Star or ?