Glow-in-the-Dark Geometry

The Big Idea

This week you'll make geometric shapes out of glow sticks. The kids will try all sizes and shapes of triangles and quadrilaterials, then lay out sticks in mystical repeating patterns on the floor. Then you'll take a trip to Egypt by stacking glowing balls. Only some numbers can make a perfect triangle or pyramid!

Supplies

- ★ 8" glow sticks: 16 per kid
- ★ 1 ½" mini glow sticks: 50 for group
- ★ Small 1 ¼" styrofoam balls: 50 for the group
- ★ 4-5 empty shoeboxes

Room Set-up: You'll need to make sure the room is fairly dark with the lights off.

Other Key Prep: You'll need to track down a few shoeboxes ahead of time.

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What's the Math?

These activities explore the following math concepts:

- ★ Shapes
- ★ Counting
- ★ Pattern recognition – both shapes and numbers
- ★ Area
- ★ Volume
- ★ Ratios

Kickoff

Intro to the kids: "What do you call a shape with straight sides and sharp corners? (Discuss) It's called a 'polygon.' Today we're going to make polygons that glow in the dark and light up the floor!"

Introducing...the Glow Stick (10-15 min)

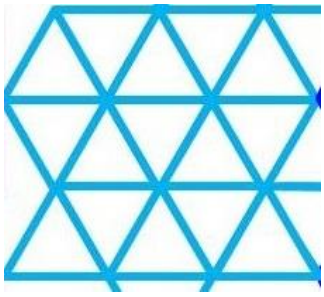
Intro to the kids: "Let's start by getting these sticks to glow. Then we're going to play around to see what shapes we can make."

- ★ Put all the glow sticks in a pile, and have the group snap them all to start the glowing. Explain that they shouldn't bend them too far or they'll crack and leak, and to shake them to even the color.
- ★ Turn off the lights and let everyone play freestyle for a few minutes to make shapes.
- ★ Ask the kids to make any kind of triangle. How many sizes and kinds of triangles can the group come up with?
- ★ Now have them try 4-sided shapes...how many sizes and kinds can they come up with?
- ★ Encourage them to make other shapes: stars with different numbers of points, houses, etc.

Hit the Floor (15-20 min)

Intro to the kids: "Did you notice how some triangles or rectangles had sides of different lengths? Maybe 2 sticks here, 1 stick there? What do you call it when all sides are the same length and make the same angle over and over? (Discuss) ***Answer:*** Those are called "regular polygons. How many others can you name?" (Squares, equilateral triangle, pentagons, octagons shaped like stop signs, regular hexagon (6), heptagon (7), dodecagon (12), etc.)
"Now that we've seen our glow sticks in action, let's decorate the floor. The thing is, there are only 3 kinds of regular polygons where you can repeat that shape with no gaps or overlaps. Can you figure out what they are?"

- ★ Turn off the lights first for full effect later. Have the kids gather their glow sticks to form shapes on the floor as a group, using 1 stick per side. Then flick off the lights!
- ★ If needed, guide them to see that only 3 shapes will work: equilateral triangles, squares, and regular hexagons. See graphics here and below.
- ★ Now have the kids rearrange all glow sticks into a lattice of equal-sided triangles, as shown here. ***Ask the kids:*** "How many sticks were used to make how many triangles?" See how they count up – tiptoeing works well.



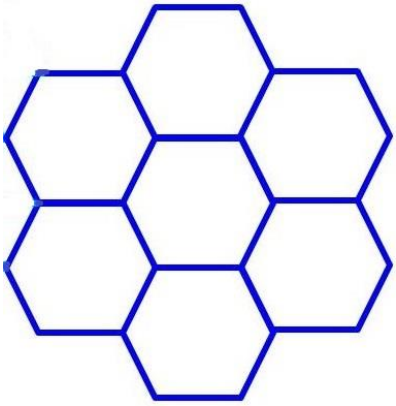
- ★ Once they've started counting, ***ask***: "What size triangles are you counting?" This will remind them to consider bigger triangles…

BONUS: "How many triangles could you make from 300 sticks?"

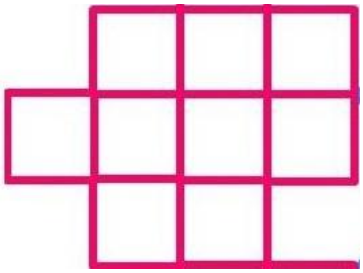
- ★ Let the kids count up triangles and sticks to figure it out.
- ★ The answer is hard because the ratio changes as the number of triangles increases: as it goes to infinity, there will be half as many sticks as you'd need if no sides were shared. You can hint: "To start, how many would you need if no sides were shared?"
- ★ The answer: as you go to infinity, you'll need 3/2 as many sticks as

triangles – half of the 3 per triangle you'd need with no shared sides. So 300 sticks should make 200 triangles, not just 100.

To the kids: "Now let's try another shape that works: the regular hexagon! What's the fastest way to make hexagons from these sticks?"



- ★ See if they think to remove sticks 6 at a time from the center of each!
- ★ In doing so, they might see that the diamond (rhombus) also works.
- ★ ***Ask the kids:*** "How many hexagons can we make from all the sticks you started with?" (Discuss) "This is why bees build their hives in the hexagon pattern: it creates the most "rooms" using the least wax, which matters because making wax is hard work!"
- ★ ***Continue***: "What was the third regular polygon that could fill the floor?" (Answer: squares) Now that you've gotten so good at this, we're going to have a race!"
- ★ Split the group into 2 teams.
- ★ Hand each group 30 glow sticks.
- ★ With the lights off, have the groups race to lay out their sticks in a square lattice!



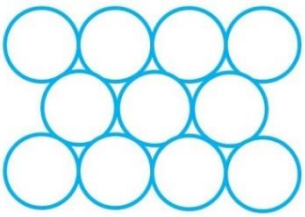
Having a Ball (15 min)

Intro to the kids: "We've been having all our fun with polygons, which have straight edges. Let's see what happens when we switch to circles…"

- ★ Turn the lights back on. Divide the kids into 4-5 groups.
- ★ Unveil the styrofoam balls and the 1 ½ inch mini glow sticks.
- ★ Have the kids snap the mini sticks and shove one into the center of each styrofoam ball.
- ★ Flick off the lights to see them glow!

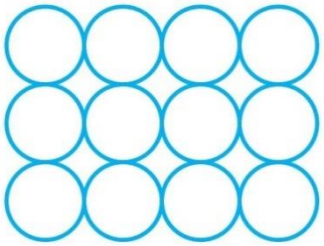
★ Hand each group an empty shoebox. With lights off, ask the kids to figure out the most balls they can fit in one layer in the box.

★ What happens? See if they get the best arrangement, as shown here. Why does it work?



★ Now have the kids lay the balls in the box in a "square lattice," i.e. with rows going up-down and left-right.

★ Did that fit as many balls? (Discuss) Why not?



★ ***Ask the kids:*** "Do these patterns look anything like the glow sticks on the floor?" (Discuss) ***Answer:*** "The first ball pattern looked like the hexagons, because the circles' centers marked off regular triangles with each other. The second ball pattern looked more like squares, since the circles' centers marked the corners of squares.

★ Group the kids into groups of 4. Give each one about 20 balls. Have the kids arrange their balls into triangular-shaped clusters, packing them as tightly as they can.

Ask the kids:

★ What different size triangles did you make? (Discuss)

★ Will any number of balls make a full triangle? Can you make one out of 4 or 5 balls?" (Invite the kids to try…the answer is no!)

★ So what numbers did work?

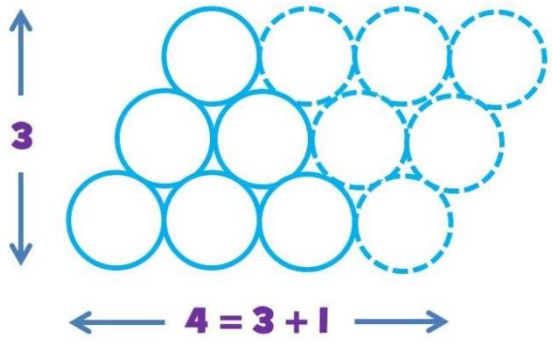
BONUS: Draw a 2-column table on the board or a piece of paper, writing the number of balls across the edge of a triangle in one column, and its total number of balls in the second column. The result:

1	1
2	3
3	6
4	10
5	15

Ask the kids, "Do you see a pattern in these numbers? Can you figure out the number of balls in a triangle knowing only how many across it will have?"

★ If they get stuck, lay 2 3-ball triangles side by side as shown to make a tilted rectangle (parallelogram):

★ …and ask how many *that* shape uses. This will hint that the number of balls in a triangle of side *s* is half of a rectangle s balls across and s+1 tall.



★ "So the total number of balls is s x (s+1) divided by 2. How many balls will we need to make a triangle with 8 on each side?" (Discuss…the answer is half of 8 x 9, or half of 72, which is 36).

★ "Are we right? Count out 36 balls and try it!" Let the kids build and experiment to test their answer.

Trip to Egypt (10-15 min)

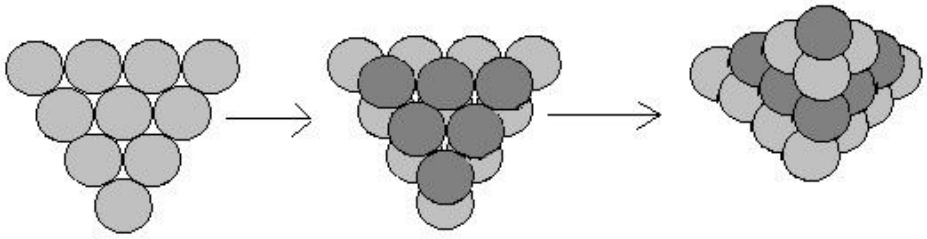
Intro to the kids: "What's been the same for all our designs so far? (Discuss…) It's all been in 2 dimensions, flat on the floor. Now we're going to go 3-D and build up. We're going to Egypt to build a pyramid!"

★ Gather everyone around in a circle and tell the kids to collect 100 balls as fast as possible, just to see how they do it as a group.

★ Lay 7 balls in a straight line against the edge of a book.
★ Have the kids build that out into a whole triangle. Lay a book along each new edge to hold the cluster in place.

Ask the kids:

★ "How many balls did that take?" (Answer, either by counting or by bonus formula: 28).
★ "Okay, now build this up into a pyramid. How many balls do you think we'll need?" Write down their guesses!
★ As the kids build, have them point the glow stick ends straight down into the gaps to fit. Stack a 2nd, smaller layer, then a 3rd, and so on until the last ball. The result should look like this:



Ask the kids:

★ Does anyone know the name of the geometric shape we're building? (Answer: a tetrahedron). In Greek 'tetra' means 4 and "hedron" means 'solid,' different from a 'gon' which is a flat shape. So a tetrahedron is a 4-*faced* shape.
★ How did we do with our guesses? (Discuss!)

BONUS: ***Ask the kids:***

★ "Starting from the bottom, how many layers of the pyramid use half the balls?" (Take guesses) Answer: The first 2 rows alone use almost half! 28+21=39 balls. "When the Egyptians built the pyramids, it took them half their time just to build the bottom 5th of the pyramid. They went faster as the layers got smaller. We had the same thing!" Great link to learn more: http://www.cheops-pyramide.ch/khufu-pyramid/khufu-numbers.html

…and the kids can take home glow sticks and balls to keep building!