Pokemon vs. Mathmon, Part 1

PATHWAYS
#15 Linear Algebra
#40 Sequences, Series, Summability
#68 Computer Science

Family Math Circle ~~~ November 2023

Pathways name our math inspirations using Mathematics Subject Classification. Mathematicians around the world label their work with library codes from MSC, https://msc2020.org/ Let us help students feel happy familiarity with each subject area!

Family Math Circle is an informal learning space where participants make advanced mathematics accessible to everyone in kind ways.

Pokemon in a Tsimshian Indigenous style by Chase Gray

Roots and Wings
Make models to ground your math. Make connections to advance in higher math.

Make missing-picture puzzles about growing creatures or patterns and connect to algebra. Describe or program the rules of your patterns with computer science tools to expand the patterns into infinite sequences.

MATH IS WHAT YOU MAKE IT!
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Words With Math Friends
Tell friends and family all about your math creations. Use these terms +"math" to find images, videos, and articles on the web.

- predictable, unpredictable, growing pattern
- recursive rule, explicit formula
- row, column, cell, table

- function, variable, covariation
- difference, second-order difference
- infinite sequence, infinite table

Interesting Choices
Mathematicians do many different things. What kind of math person will you be today?

Make up creatures who grow unpredictably or Mathmon who grow by the number. Work with concrete creatures or abstract shapes. Model visual patterns with numbers, or number patterns with pictures and objects. Choose abstract math to imagine the impossible at the end of infinity, or choose applied math, science, and engineering to study realistic large numbers. Use a recursive rule or an explicit formula for different points of view on sequences.

Toolbox

Physical (gray=optional)
Paper, graph paper, colored pencils or markers.
Counters such as coins or beans, pattern blocks.
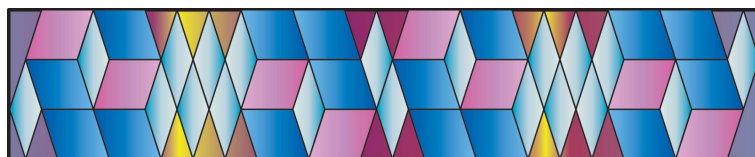Virtual
A collection of growing patterns
https://www.visualpatterns.org/
Virtual math pad with tiles
https://mathigon.org/polypad
Nature by Numbers https://youtu.be/kkGeOWYOFoA

NaturalMath.com/circles/
Extra activities, videos, math connections, books, and other resources for math circle leaders.

Pattern Block Frieze Groups by Paula Biardell Krieg

Math Circle: Pokemon vs. Mathmon

0. Warm-up: Surprising Creatures of Earth

Some creatures or plants change a lot as they grow up. For example, an egg grows into a tadpole and then a frog. If space aliens saw tadpoles for the first time, they'd never guess what that baby will grow into! Let's pretend to show our space alien friends how surprising our planet can be.

Recall or find some Earth creatures that change a whole lot between their life stages. Can you guess the next form of the creature below?
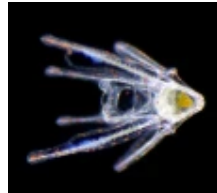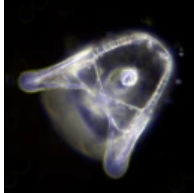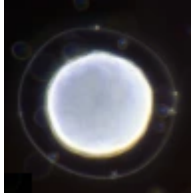
⚠ SPOILER Want to look up what this beautiful creature grows into? The scientific name is Mespilia Globulus.

Images: LadyOfHats at Wikipedia; Jamie Craggs et al. at Nature

1. Pokemon Surprise

|						
Bulbasaur	*Ivysaur*	*Venusaur*	Here are some Pokemon. Bulbasaur grows into Ivysaur who grows into Venusaur. Charmeleon grows into Charizard.	**?** *???*	*Charmeleon*	*Charizard*

Can you figure out what Pokemon grows into Charmeleon?

Images: Nintendo

2. Mathmon Puzzles

Space aliens who don't know about Earth creatures couldn't possibly *predict* what the tadpole grows into. No matter how clever, there is no way for us to figure out who is missing from our Pokemon sequence if we don't already know that story or look it up. Let's make *predictable* mathematical monsters, *Mathmon*, and compare them to the *unpredictable* creatures.

1. Cut or tear off a strip of paper. Fold it in two, fold it in two again, and unfold. You should have four *cells* in a *row*, like a comic strip. Sketch a made-up creature in the first cell. Choose more detailed art or a quick stick figure—whatever helps you think.

2. In the second cell, draw how your creature grows. Its tail can get longer; it can sprout an extra ear or a couple of legs, etc. Choose what to change in number, shape, or size: your creature's *variables*.

3. In the third and fourth cells, make your creature grow again and again! <u>Choose</u>: Do you try to make your creature grow in <u>unpredictable ways</u>, like Pokemon or frogs? Or do you try to make it grow <u>exactly the same as before</u>?
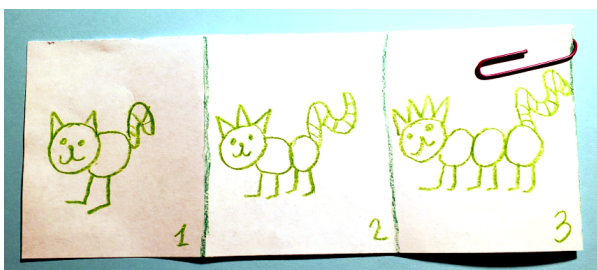
Fold your fourth cell down to hide it, and fix it in place with a paper clip. Trade these puzzles with your math friends. Invite them to describe or sketch the creature in the hidden cell, and tell you what they notice about your creatures.

Mathmon forms 1, 2, 3

⚠ SPOILER Your creatures might not be as predictable or surprising to others as you've thought. That's because it takes a while to learn how to predict rules, make predictable rules, and make surprises.

3. One Lone Variable and One Single Rule

Do you want to make absolutely sure your growing Mathmon is predictable? Make one and only one thing grow on it, exactly by the same rule each time that one thing grows.
For example, on the Mathmon you see here, only the tail grows, and we add 2 parts to it each time.
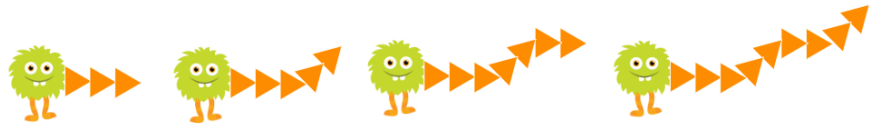
If you get bored with your one lone *variable*, make up a fancier growing *rule*. Can others figure out your rule? Does your rule allow your Mathmon to keep growing beyond its fourth form? Could you imagine it growing to Form #100? Infinitely?

4. Covary Together

Get together with a few math friends who grew different parts on their one-variable Mathmon. *Combine* these parts (ears, legs, tail, etc.) on the same drawing. And then:

1. Trade the parts around the group.
2. Explain your rule to the person to whom you gave your part.
3. Draw how the part that was given to you is growing.

There are many ways to explain rules to one another. You can say, "Add two legs." You can write +2. You can draw a picture.

Body	Ears	Legs
1	2	2
2	3	4
3	4	6
4	5	8
5	6	10
6	7	12
7	8	14
8	9	16
9	10	18
10	11	20

Together, figure out what your creature will look like when it grows to Form #100. There are many ways to figure that out. You can draw 100 cells. You can use your rules 100 times. You can program your growing rules into a spreadsheet and run the program for 100 steps. Or you can figure out an *explicit formula* to jump to any step you want.

You might notice how parts grow together, that is, *covary*. For example, when the Mathmon in our picture grows to its Form #100, it will have a looong body with 100 circles. There are always twice as many legs as those circles. That is, there will be 2*100 legs. There also will be 1+100 ears. Do you see why?

5. Grow by the Number, Grow by the Shape

Shapes are not creatures, but we can think of them growing, too. Shapes can grow in many ways.

growing an extra side (polygons)

growing a border (tile patterns)

branching to grow (tree fractals)

growing in one direction (frieze patterns)

Draw, build, or find your own growing shapes.

- Make growing shapes with blocks, coins, graph paper, or found treasures (shells, leaves, or sticks).
- Look for growing patterns in arts, crafts, traditional designs, nature, music, clothes, architecture, etc.
- Change only one thing about your shape, or covary several things.
- Invite your math friends to predict the next form and Form #100 with you.

~ Examples ~ Questions ~ Problems ~ Stories ~ Conjectures ~ Models ~ Art ~ Formulas ~ Graphs ~

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