Created by Eric Muller, Chantal Buteau, and Elisa Rocci, Brock University, Canada, under the ***Mathematics Knowledge Network*** (**www.mkn-rcm.ca**). February 2019.

Choose Your Cupcake Carefully!

Because her mother works in the afternoons, Bhanu has a sitter called Amira. Bhanu really likes Amira and looks forward to those days when she has a trick or surprise for her.

Day 1

This week, on Monday, when Bhanu comes home she finds two identical sealed boxes on the kitchen table. Amira explains that one of the boxes contains her favourite cupcake, a chocolate cupcake with chocolate icing. The other box contains broccoli, not Bhanu's favourite vegetable!



Amira tells her to pick one of the boxes, and whatever is inside will be her snack. Bhanu is not allowed to open or touch the boxes. What is Bhanu's chance of choosing the one with the chocolate cupcake?

Write down your answer with explanation:

_____

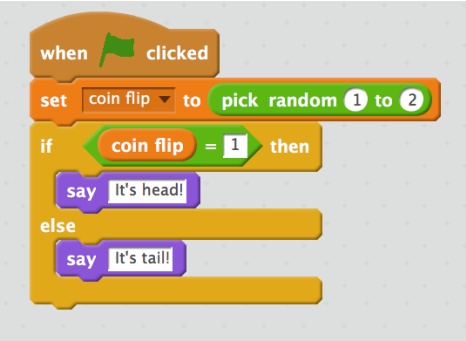
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_____

Bhanu remembers that, with her teacher, she had explored a similar problem tossing a coin using Scratch on a computer at school.

Click here[1] to open the program, then click on 

to see the code. You should see something like this:



Here is the idea: When we toss a coin, there are two outcomes: heads or tails. Therefore, we can say that the number 1 represents heads and that the number 2 represents tails, and we allow our program to randomly choose either the number 1 or 2 to simulate flipping a coin.

Now click on  ten times and record your results in the table:

Flip #	Head (1) or Tail (2)?	Flip #	Head (1) or Tail (2)?

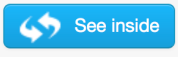
[1] **www.scratch.mit.edu/projects/252371559/**

How many heads did you get?_____

How many times did you flip the coin?_____

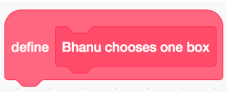
Is it what you expected? Explain: _____

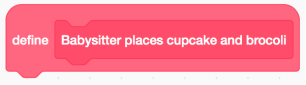
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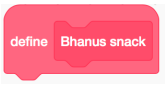
Bhanu starts to amend her Scratch program to see a chocolate cupcake and broccoli. Open her Scratch program[2], click on 

to open the code, and complete it as follows:

1. Click on Bhanu 

(bottom right – you might need to scroll down to see it among the other "sprites") to show the code displayed in the middle, and also clicking  (top right) to see more of the code.
2. Look at the code under. 

.
3. Complete the code under 

and under 

by dragging the missing pieces.

Run the program ten times by clicking the green flag  (you can also first click on  at the top right to see the simulation in full screen), and record your results:

Attempt #	Broccoli or Cupcake?	Attempt #	Broccoli or Cupcake?

What did you find? How many times would Bhanu have gotten the chocolate cupcake? _____

How many times would she have gotten the broccoli? _____

Is it what you expected? Explain: _____

_____

By the way, we call this a *computer simulation* because it consists of only pictures of the real things.

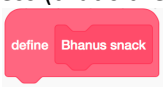
[2] **www.scratch.mit.edu/projects/243992883/**

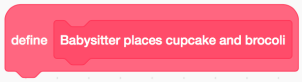
Bhanu thought that she should try to have her program simulate not only one trial in one click, but many. Now open her other Scratch project[3] and click on 

to open the code. Bhanu was almost done with her program, which keeps track of her simulation of five attempts to get a cupcake. Help Bhanu complete her program:

4. Click on Bhanu 

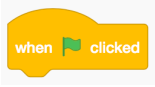
to see the code displayed in the middle. Bhanu's code to select one box on the table is already done for you.
5. Read the code under 

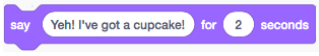
. You will notice that the overall code will simulate five attempts and will keep track of the success (that's the cupcake!) and failure (the broccoli).
6. Complete the code under 

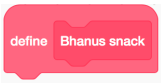
by dragging the missing pieces. And fix the code under 

.

Now run the program. Does it work? This program runs five times on one click and keeps track of her snacks. Run it a few times.

7. Modify the code to run 100 times (check the code under 

). You might want to run a "faster" simulation and change the waiting times of 

to 0 seconds (and the same for the other two purple commands) in 

….

Now run the program by clicking the green flag , and record your result:

Out of 100 attempts, Bhanu got _____ cupcakes and _____ broccoli.

Repeat this simulation by clicking on the green flags ten times, and record your results in the table:

Attempt #	# of Cupcakes	# of Broccoli

[3] **www.scratch.mit.edu/projects/243974530/**

The results are (*circle your answer*): i) exactly the same, ii) approximately the same, or iii) very different.

Why do you think so? _____

_____

Amira is really surprised that Bhanu can show that she has about a 50-50 chance of choosing the box with the chocolate cupcake.

Day 2

The next day, Tuesday, Amira sets up a different challenge for Bhanu, and she finds three identical sealed boxes. Amira tells her that her favourite chocolate cupcake is in one of the boxes, and that the other two boxes contain broccoli. Again, Bhanu has to pick a box and accept whatever was in it for a snack. Bhanu hopes that her chance of getting the chocolate cupcake is still about 50-50, but wants to explore the problem, using yesterday's Scratch simulation.

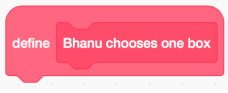
Modify the program to simulate the new situation with three boxes as follows:

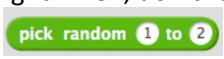
8. Click on 

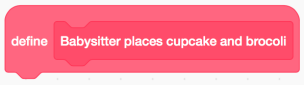
, then click on 

to place a third box on the table. Do the same with the second broccoli: click on the icon, and click on 

to give the babysitter a second broccoli.
9. Click on Bhanu 

to see the code displayed again.
10. Modify the code under 

to add the possible choice of a third box by dragging the code pieces to the right. Then, don't forget to look at the very first code line; you must modify something therein: 

.
11. Modify (only one thing to change!) the code under 

.

Now run the simulation 100 times (by only one click!), and record your results:

Out of 100 attempts, Bhanu got _____ cupcakes and _____ broccoli.

Are you surprised that the chance to get the chocolate cupcake has changed so much? What do you conclude is Bhanu's approximate chance to pick the box with the chocolate cupcake? Record your answer.

_____

_____

Day 3

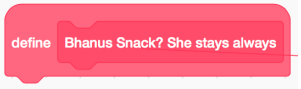
Amira is so impressed with Bhanu's exploration with Scratch that on Wednesday, she again has three sealed boxes, one with Bhanu's favourite chocolate cupcake and the other two with broccoli. However, Amira changes the way that Bhanu is to select a box. This is how it works: Bhanu selects a box and then Amira, who knows which box contains the chocolate cupcake, opens one of the two boxes which is not chosen by Bhanu, and which contains broccoli. Amira, always so kind, allows Bhanu to change her selection, if she wants to. The BIG question for Bhanu is whether she will have a better chance of getting the chocolate cupcake if she stays with her first selection, or if she switches to the other unopened box. How could she explore this?

Again, she uses Scratch to simulate the situation. First, she decides to always keep her first choice.

Open her Scratch program[4], click on 

to open the code, and amend the program to simulate it as follows:

12. Click on Bhanu 

to see the code displayed.
13. Complete the code in 

as to whether Bhanu gets a cupcake or not, depending on her initial box selection, by dragging the code pieces. Read the comments to help you.
14. Check that it works.
15. Modify the code to simulate 100 attempts at getting a cupcake.

Run it ten times and record your results:

Attempt #	# of Cupcakes	# of Broccoli

What do you think? Has Bhanu improved her chances of choosing the chocolate cupcake compared to Day 2?

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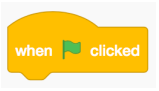
[4] **www.scratch.mit.edu/projects/243998387/**

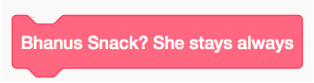
Are you surprised? _____

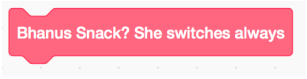
Why (or why not)?_____

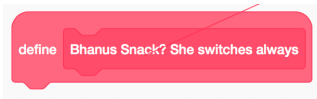
_____

Now Bhanu needs your help to explore whether the strategy of always switching box would be better. Amend the code to simulate this situation:

16. Bring "*Bhanu's Snack? She switches always*" in the code under 

by switching the two code blocks, 



.
17. Complete the code in 

by dragging the pieces found underneath it. Read the comments to help you. What happens if Bhanu initially picked the box with the cupcake?
18. Check that it works.
19. Modify the code to simulate 100 attempts at getting a cupcake.

Run it ten times, and record your results:

Attempt #	# of Cupcakes	# of Broccoli

What do you think? Has Bhanu improved her chances of choosing the chocolate cupcake compared to Day 2?

Are you even more surprised? _____

Why (or why not)?_____

_____

So, if you were Bhanu, what would you do? Keep or switch your first choice? ***Tonight, try it with your parent... and see if your parent would end up eating broccoli or a chocolate cupcake!***