Classroom Activity: Teacher Guide: Coin Toss-up

If you toss a coin, there is a fifty-fifty chance it will land tails-side up. But what if you toss it five times, can you predict how often you'll get one tails and four heads versus three tails and two heads? In this activity, use a coin and some graph paper to explore how the accuracy of predictions is influenced by sample size.

Activity's uses:	Classroom demo or small group exploration
Area(s) of science:	Math
Difficulty level:	4
Prep time:	<10 minutes
Activity time:	30-45 minutes
Key terms:	Probability, statistics, independent trials, random process, histogram

Background Information

If we are lucky, the questions we have to answer on a daily basis have only one of two outcomes. Will the grocery store be open or will it be closed? Will my football team win or lose? How probable is it that either of these outcomes will happen, and how can we calculate the answer? The solution is to use the rules of probability, the branch of mathematics that deals with calculating the likelihood of any single event happening.

Flipping a coin is an easy way to demonstrate the concepts of probability. The probability of flipping heads is 0.5, or 50% of the time, and the probability of flipping tails is also 50%. Each flip is also independent of the flip prior to it. This means that the next flip of the coin doesn't depend on the result of the previous flip. But if you flip a coin a number of times, is it equally likely to come up all tails compared to a combination of heads and tails? The answer is no, but there are ways to calculate the probability of each combination. All of these definitions contribute to why flipping a coin is a random process-it is because of indeterminacy in resulting combinations of coin flips, meaning not all combinations are equally likely.

Is it possible to predict accurately a combination of flips based on a prior series of flips? In this math activity, the students will investigate the probabilities associated with flipping coins. Each of the student groups will start by flipping a coin five times, noting the results, and repeating this process nine more times. Then they will count and plot the number of times every combination of heads and tails occurs. The students will then execute a series of five coin flips ten more times, for a total of 20 series of coin flips, and determine if they can accurately predict probability based on a small number of series.

For Discussion

This math activity can be used as a starting point for a variety of science and math discussions. Here are a few sample questions that can be used to start a discussion:

- What is the definition of mathematical probability?
- What are some examples where you made a decision based on probability?
- Who is Jacob Bernoulli and what is a Bernoulli trial?

Materials

- A few coins for each student group
- Data tables from the student activity directions for each student group to record their data
- Graph paper (1 package)
- Pencils

What to Do

Prepare Ahead (<10 minutes)

1. Print a copy of the student activity directions for each demo or small group. Each group will be able to record their data in the tables provided in the student directions.
2. Allot each group a few coins, the data tables, two sheets of graph paper, and a few pencils

Science Activity (30-45 minutes)

1. Each student group should have a few coins, a notebook, and a few pencils. Have the students practice flipping several coins for a few minutes, then ask them to choose the one that they think works best. Once the group chooses a coin, they should stick to that coin for the duration of the activity.

Coin Flip Series #	Results	Coin Flip Series #	Results
1		11	
2		12	
3		13	
4		14	
5		15	
6		16	
7		17	
8		18	
9		19	
10		20	

Table 1. Coin flip data

2. Have students in each group flip a coin five times and write down the results of each flip in first line of Table 1. For example: heads, tails, tails, heads, tails could be noted as HTTHT.
3. Each group should repeat step 2 nine more times, making sure that all of the results for each series of flips are recorded in Table 1 on the corresponding line.
4. Once all the groups have finished ten series of flips, count the number of times each of six possible combinations of heads and tails occurs. Note that HTTHT and TTTHH would both be counted as two heads, three tails. Record the data in Table 2 under column 1 ("Count for Series #1-10").

Combination	Count for Series #1-10	Count for Series #11-20	Total Count (Series #1-20)
5 Heads			
4 Heads, 1 Tails			
3 Heads, 2 Tails			
2 Heads, 3 Tails			
1 Heads, 4 Tails			
5 Tails			

Table 2. Count data for each combination of heads and tails

5. Now have each group graph the count data for each combination (the result is called a histogram) using a sheet of graph paper.
6. Repeat steps 2 and 3 another ten times for a second series of flips (#11 through #20). Record the data in the second column of results on Table 1.
7. The groups should then count the number of times each combination occurs in the #11 through #20 coin flip series and add that information to Table 2 under the second column. Then, add the first and second columns in Table 2 and place the sum in the third column of Table 2. This is the count data for all 20 series.
8. Each group should graph the data for the 20 series on a second histogram using another sheet of graph paper.
9. Compare the two histograms. Is there a difference? What does this tell you about making conclusions based on a small number of series?

Expected Results

Each group should have a plot approaching a binomial distribution, or bell-shaped curve, for the 20 series of flips. But the plot for the series of ten may not have the typical bell-shaped feature. The difference in the histograms illustrates the concept that it is not accurate to base predictions on a small amount of data.

For Further Exploration

This science activity can be expanded or modified in a number of ways. Here are a few options:

- Continue for 30 series and then plot the data. What does the plot look like and how does it compare to the plot for the 20 series?
- Redo the activity with seven coin flips in each series and a total of 20 series. Is the resulting histogram similar to the one with 20 series of five flips per series?
- Write a computer program to generate the data rather than flipping a real coin.

Downloads and Links

- Coin Toss-up Facilitator / Educator Guide PDF
- Coin Toss-up Student Guide web page or PDF

Credits

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