CURIOSITY AT HOME

ROLLING WITH IT

Many board games require you to roll one or more dice to decide what happens next – whether that's how far your playing piece moves, how many points you earn, or whether or not a certain event happens. Game designers can change the probability of different events happening by changing how many dice you roll. In this activity, you will compare the probability of rolling different scores on different numbers of dice.

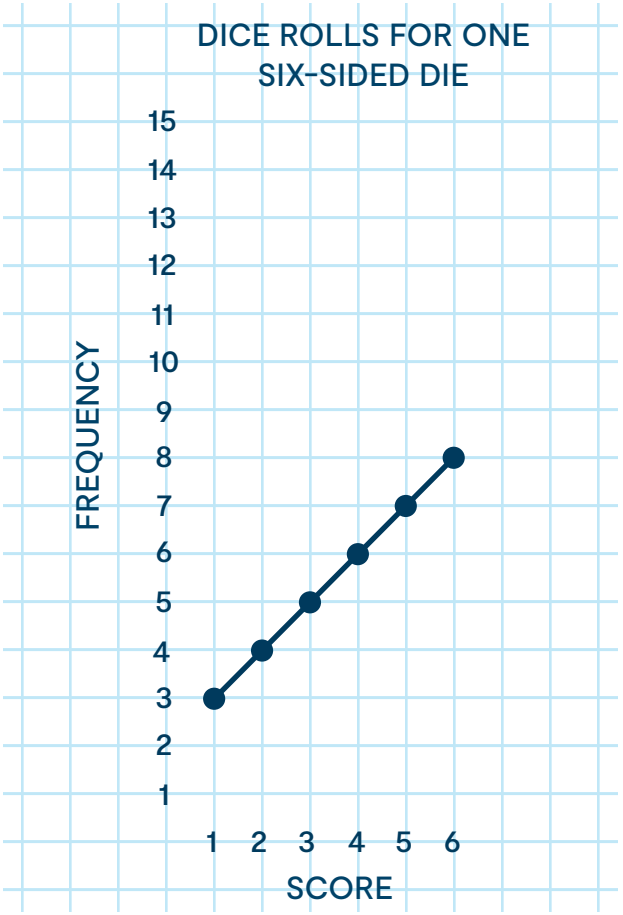
MATERIALS

- 2 six-sided dice
- 6 coins
- 3 sheets of graph paper (template included in activity)
- Science notebook or paper
- Something to write with in at least 2 different colors

PROCEDURE

- Make a prediction. If you roll a die (the word for a single dice) 30 times, how frequently will each number be rolled?
- Represent your prediction by creating a line graph on a sheet of graph paper.
  - Give your graph a title
  - Label the x (horizontal) axis as "score" with space for scores of 1–6, and the y (vertical) axis as "frequency" with space for frequencies of 0–15.
  - Chart a line showing your prediction, and label it "hypothesis".
  - For example, if you think that larger numbers will get rolled more frequently, your line might go up diagonally. Depending on what you expect to happen, your line might be straight or curved.

Example Prediction Graph



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- Test your prediction out. In your science notebook, copy the table below or create your own.

Roll a 1	Roll a 2	Roll a 3	Roll a 4	Roll a 5	Roll a 6

- Roll the die, and make a tally mark in the proper column. Repeat this process until you have rolled the die 30 times.
- Using a different color writing tool, chart a line graph of your actual observed dice rolls over your original prediction graph. Was the actual outcome the same as you predicted, or different?
- Next, use a new piece of graph paper and make a prediction. If you rolled two dice 30 times each, what would be the frequency of the sums of those two dice? Make a graph of your prediction.
  - This time, your x axis of "score" should have space for totals of 2–12. Keep your frequency at 15.
  - Make a line showing your prediction and label it "hypothesis".
  - Just like last time, the shape of your hypothesis line will depend on how frequently you think different outcomes will happen.
- Now it's time to test the hypothesis. In your science notebook, copy the table below or create your own.

Sum = 2	Sum = 3	Sum = 4	Sum = 5	Sum = 6	Sum = 7	Sum = 8	Sum = 9	Sum = 10	Sum = 11	Sum = 12

- Roll two dice and calculate the sum total. Make a tally in the proper column of your table. Repeat until you've rolled the dice 30 times.
- Using the same piece of graph paper but a new color, graph out your results. Is what you saw the same as what you predicted, or is it different?

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EXPLORE MORE

- This time, we want to see what would happen if you rolled six 2-sided dice. But since 2-sided dice do not exist, you'll be flipping coins, with heads being worth a score of 1 and tails being worth a score of 2.
- Graph out your prediction on a new piece of paper.
  - Your x axis of "score" should have space for totals of 6–12. The y axis should still be 30.
  - Make your hypothesis line. Based on what you've seen so far, what do you expect the frequency to look like?
- Test your hypothesis. Make a table for results ranging from 6–12. Flip 6 coins, and calculate the total score, with heads being worth 1 point and tails being worth 2 points. Record your score with a tally mark, and repeat until you've done this 30 times.
- On the same piece of graph paper, graph out your results in a new color. How does your actual frequency data compare to your prediction?

WHAT'S HAPPENING?

- If a game designer wants a medium score to happen most frequently, they will instruct you to roll multiple dice. The totaling of multiple dice evens out the probability of an event. On the other hand, if events should be equally likely and have unpredictable outcomes, having players roll a single dice is a better strategy. What if you want equally likely outcomes but need more than 6 potential results? You can make dice with more than 6 sides!

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K–2 GRADE EXPLORATION

- Random means that you cannot predict the result of an action. Is flipping a coin random? How about rolling dice?
- Try to predict the result of flipping a coin. Use tally marks to keep track of how many times you guess right and how many times you guess wrong.
- Try predicting the result of a dice roll. Tally your right and wrong guesses. How does this number compare to when you tried to guess the results of coin flips?
- Why do you think it's possible to correctly predict the results for coin flips more often than for dice rolls?
- Can you think of any other examples of things that are random?

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3–5 GRADE EXPLORATION

- Let's look at some more types of dice where the maximum sum is 12. Follow this link for Google's official dice roller. Click on the large 6-sided die to delete it, and click on the numbers within colored shapes to create dice with that number of sides. To start, click the red number 12 to bring up one 12-sided die.
- Click the "roll" button to roll the die. Do this 30 times. Track and then graph the frequency of results.
- Click on the die to delete it, and then click the green triangle with the number 4 in it three times to bring up three 4-sided dice.
- Roll the dice 30 times. Track and graph the frequency. How does the graph for the single 12-sided die compare to the graph for the two 6-sided dice? How do they compare to the three 4-sided dice? The six coins?
- Why do you think these methods of rolling all got different results?

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[1] https://g.co/kgs/4vN6VT

CURIOSITY AT HOME

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6–8 GRADE EXPLORATION

- There are three different methods of calculating the middle of a set of numbers, and they are called the mean, median, and mode. Calculate each of these for the different combinations of dice or coins.
- To calculate the mean, add all the rolled results together and divide by the number of times you rolled (in the case of our experiments, 30). For example, if you rolled 10 times and got the results 1, 2, 4, 4, 6, 7, 7, 8, 10, 12 then you would calculate the mean by adding those together (which equals 61) and then dividing by 10 to get a mean of 6.1.
  - Do all combinations of dice have the same mean? Why might this be?
- Calculate the median by making a list of all results in numerical order. Then, cross off the highest and lowest numbers on the list, and repeat until only one number is left in the middle. For example, if your list of results was 1, 1, 2, 3, 4, 5, 5, 7, 8, 9, 10, 11, 12 then your median would be 5 because that's the number in the middle. Because you have an even number of results in your data set, you will have two numbers left at the end. Average them out by adding them together and dividing by 2.
  - Do all combinations of dice produce the same median? Why might this be?
- To calculate the mode, look at your tally marks and see which result was rolled most often. For example, if your list of results was 1, 1, 1, 2, 4, 4, 5, 5, 7, 7, 9, 10, 10, 11, 12 then your mean would be 1, because it showed up most frequently. Technically, a set of dice rolls can have more than one mode if more than one number shows up most frequently.
  - Do all combinations of dice produce the same mode? Why might that be?
- Was the mean, median and mode the same or different for any given set of dice rolls? Why might we want to calculate all three instead of just the mean?
- Can you come up with two imaginary sets of dice rolls where the mean and median are identical but the modes are very different?
- · Why did the different methods of rolling not all have the same mean, median, and mode?

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