Introduction

Each time you draw a card in a card game you have a certain chance at getting the card you need to beat your opponent and win the game. Consider the game “Go Fish,” being played with a regular deck of playing cards. The object of the game is to win the most four-of-a-kind sets by asking your opponent for matching cards or by drawing matching cards from the deck. At the end of the game, the player with the most sets of matched cards wins. If you want to win the game, you need to increase your chances of getting matching cards, but how?

By understanding how chance is related to math, you can learn to play with a winning strategy. For example, what if you have three kings and one queen in your hand and it is your turn to ask for a card, which one should you ask your opponent for? At first you might think that because you have more kings, you should ask for those, but it is actually better to ask for the queen! Why? Because you have a better chance of getting it!

Here is how you can figure it out: There are only four of each kind of card in the deck, so there are four kings and four queens total. If you have three kings in your hand, as shown in Figure 1 below, there is only one king left. Since only one queen is in your hand, there are three queens left. You have one chance to get a king, but three chances to get a queen out of the remaining cards. That is why you have a better chance of getting the queen than the king if you ask for it.

![Figure 1. If you are playing "Go Fish" and have one queen and three kings in your hand, there are three queens and one king left in the deck or in your opponent's hand.](image)

At first this sounds very confusing, but the more you try it you will see how it works. This strategy is based on something called probability, which is how mathematicians study how likely an event is. There are many events that can be described by probability and math, especially in games we like to play. The chance that you will draw a certain type of card in a game of "Go Fish", the chance that you will roll a six in "Chutes and Ladders," or the chance that you will spin green when playing "Twister" are all probabilities.

The nice thing about a probability is that you can measure it by counting and using some very basic math, like addition and division. In the example above, I knew that there were four kings in a deck of cards because I can count them. I can use addition and subtraction to know how many I have left. In this mathematics science project, you will measure the probability of drawing specific types of cards from a deck. You will choose which cards to try for, and then measure your success at drawing the card. Which cards will be the easiest to draw? Which will be the most difficult? Will your chances of drawing the card be related to how many of that type of card are in the deck? How can probability help you choose the right strategy?

Terms and Concepts

- Chance
- Strategy
- Probability
Questions

• What is probability?
• How can you use probability to make a better strategy for winning at a card game like "Go Fish"?
• In a standard deck of 52 playing cards, how many chances do you have of drawing a card that is a spade?

Materials and Equipment

• Standard deck of playing cards
• Calculator
• Lab notebook

Experimental Procedure

1. Prepare the deck of cards for your experiment.
   a. Count the cards to make sure the deck is complete (each deck should have 52 cards total).
   b. Remember to take out the jokers!
   c. Shuffle the deck three times and set aside.
2. In your lab notebook, make a data table that is similar to Table 1 on the next page. You will be recording your results in this data table.
   a. Decide which types of cards you want to investigate. You can investigate the ones shown in Table 1, or you can pick different types of cards.
   b. For each type of card you choose to investigate, make a column for it in your data table, as done in Table 1.
   c. For each type of card in your data table, count how many of that type of card there are in the deck and write this number in your data table.
3. From your data table, pick a type of card to investigate. Draw cards from the top of the shuffled deck and flip them over one at a time, counting as you go. When you get to the type of card you are looking for, stop and write down the number of cards you have drawn in your table. This will be your first trial.
4. Shuffle the deck of cards three times again and repeat step 3 nine more times to get a total of ten trials for that type of card.
5. Repeat steps 3-4 for each type of card you would like to test (that is, for each column in your data table).
6. Now you will want to add together the number of cards drawn for the ten trials for each type of card you tested (for each column). Write your answer in the "TOTALS" row of your data table. Are the numbers similar or different?
7. Next, you will want to calculate the average number of cards drawn for each type of card. Do this by dividing the number on each "TOTALS" box by ten, and writing the answer below in the "AVERAGES" box of the data table.
   a. The average is a way to combine the results of all of your trials into one number, which will be useful for graphing and understanding the results of your experiment.
8. Now make a graph of your data to help you analyze it.
   a. You can use a bar graph to show the average number of cards that were drawn for each type of card you tested. On the left side of the graph (Y-axis) put the average number of cards drawn and on the bottom of the graph (X-axis) put the type of card. Use one bar for each type of card and draw the bar up to the corresponding number on the left (Y-axis) of the graph.
      1. You can make a graph by hand or use a website like Create a Graph to make a graph on the computer and print it.
   b. You can also make a line graph showing how the number of cards drawn compares to the number of that type of card in the deck. On the left side of the graph (Y-axis) you will put a scale for the average number of cards drawn, and on the bottom of the graph (X-axis) you will put a scale representing the number of each type of card in the deck. Did you need to draw more or less cards to choose cards that were rare compared to cards that were common?
9. Interpret your results and try to make conclusions.
   a. Which cards were the most difficult to draw? Which cards were the easiest, or most likely, to draw?
   b. Did you need to draw more or less cards to choose cards that were rare compared to cards that were common?
   c. Were there any similarities or differences between different types of cards and the likelihood that you could draw them?
   d. Did the probability of choosing a specific type of card change depending upon its representation in the deck? Make a conclusion.
<table>
<thead>
<tr>
<th>Type of Card:</th>
<th>Red Cards</th>
<th>Black Cards</th>
<th>Face Cards</th>
<th>Spades</th>
<th>Kings</th>
<th>Queen of Hearts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number in Deck:</td>
<td>26</td>
<td>26</td>
<td>12</td>
<td>13</td>
<td>4</td>
<td>1</td>
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<td>Trial 1</td>
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<td>Trial 2</td>
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<td>Trial 3</td>
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<td>Trial ...</td>
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<td>Trial 10</td>
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<tr>
<td>TOTALS</td>
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<tr>
<td>AVERAGES</td>
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</tbody>
</table>
Variations

• A more advanced way of showing the results of your experiment would be to make histograms, which are a type of graph to show distributions. They are especially useful for visualizing probabilities. Try making a separate histogram for each type of card you tested. Do this by graphing the number of cards drawn for each trial separately in a bar graph. When all of the bars are lined up next to each other, what does the overall shape of the distribution look like?

• The probability of drawing a particular type of card also depends upon the number of cards drawn each time. Try this science project again but this time see how your chances of drawing a particular card change as you draw more cards each time. Try drawing samples of 3 cards, 5 cards, or 7 cards. Do your chances improve as more cards are taken?

• Probabilities also change as cards are removed from or added to the deck. Try this science project again, but this time remove cards from the deck before your experiment. Try using two decks of cards combined together. Does your data change? Why or why not? Try removing select cards from the deck, like taking out half of the red or black cards, before doing the experiment. Will this change your chances? What if you left the Jokers in the deck? How would this change your results?

• Probabilities can change your strategies for playing a card game. Can you do an experiment to show how probabilities can help you choose cards when playing “Go Fish”? What about other popular cards games like War, Memory, or Solitaire? Can you develop rules for a winning strategy? Can you invent your own card game based on probabilities?