**Script**

Hi everyone. Imagine that you are trying to impress your friends with your ability to predict what will happen if you roll a die a certain number of times. For example, suppose you win if you roll 5 or 6 and you lose if you roll 1, 2, 3, or 4. Let's say you roll the die 5 times and you win 2 times and lose 3 times. What exactly is the probability of that happening? Today, I will help you understand how to answer questions like this one. This is called binomial probability.

First, you need to understand trials and outcomes. A trial is something you do. For example, you roll a die\* [point to trial image]. An outcome is what happens on the trial. For instance, if you roll a die (the trial), the outcome\* could be that you rolled a 4 [point to outcome image]. (slide 1)\*

Second, you also need to think about success and failure. A success is defined, by you, as one or more of the possible outcomes. For example, a success of rolling the die could be that you roll a number greater than 4\*. That means, if you roll a die, and get a 5 or 6 [point to successful rolls], a success has occurred. On the other hand, a failure occurs on any trial that is not a success. So, if you defined success as rolling a number greater than 4\*, failure would occur if you rolled\* a 1, 2, 3, or 4 [point to failed rolls]. (slide 3)

Next\*, we should figure out the probability of success. The probability of success is the number of success outcomes divided by the total number of outcomes\* (including the success outcomes) if all the outcomes have an equal chance. [point to first equation]. In this case\*, there are 6 equally likely outcomes and 2 of them are successes [point to second equation], so the probability of success\* is 2 out of 6 or one-third. We can expect a 5 or a 6 to come up on about one-third of the times the die is rolled. The probability of success can be symbolized by the letter P. (slide 4).

Similarly\*, there is a probability of failure. This is\* the probability of success subtracted from 1 [point to first equation]. So, in our example, the probability of failure\* is 1 minus 1/3 which\* is 2/3 [point to second equation]. The probability of failure can be symbolized as 1 minus P. (slide 5).\*

Now you know how to determine the probability of success\* (symbolized as P) and the probability of failure\* (symbolized as 1 minus P). (slide 6)

The next concept you need to know is sequence\*. A sequence is what happens when you conduct several trials, one after another, like rolling a die 5 times in a row. For each trial, we have either a success or a failure, so the sequence reports what occurred. For example\*, say we rolled a die 5 times in a row and rolled a 2, then a 4, then a 6, then a 2, and then a 5 [point to the die]. The sequence would be\* failure, failure, success, failure, success [point to the sequence outcomes]. (slide 7).

A sequence, like the previous example, has a probability\* of occurring, which is called the joint probability of a sequence. This can be found by multiplying the probabilities of each individual event. Let’s take the previous example. We had\* failure, failure, success, failure, success [point to first line]. Now, we multiple the probability of each happening, so we get\* two-thirds (for failure), times two-thirds (for failure), times one-third (for success), times two-thirds (for failure), times one-third (for success) [point second and third line]. We can also write\* this as one-third squared times two-thirds cubed. So, the joint probability of this particular sequence occurring\* is 8 out of 243. (slide 8). \*

We can compute the probability for any specific sequence. So, let's say the number of trials\* in a sequence can be symbolized by the letter N and the number of successes\* in those trials is called R and the number of failures\* is N minus R. To figure out the probability of any sequence, you can use the formula\* displayed on the screen [point to formula]. We multiple the probability of success (P) by itself R times, then we multiply the probability of failure (1 minus P) by itself N minus R times, and we finally multiple those two numbers together. This is called the joint probability of a sequence. (slide 9)\*

Now you know how to compute the joint probability of a sequence of successes and failures. The next step is to figure out how many different sequences (that is, patterns of successes and failures) have that same number of successes out of N trials. For example\*, there are three different ways that we can have 2 successes from 3 trials: \*

success, success, failure [point to first line]\*

success, failure, success [point to second line]\*

failure, success, success [point to third line]

As you can see, in each sequence, there are 2 successes and 1 failure. The number of different sequences having R successes in N trials is called the number of combinations\*. In this example, there are 3 combinations for a sequence having 2 successes out of 3 trials [point to equation]. (slide 11)\*

The number of combinations may be simple to work out by hand when there are just a few trials, like our previous example, but what if I asked you how many different combinations can occur for 2 successes in 5 trials? In cases like this, having a formula\* to find the number of combinations is quite helpful. This formula\* is N factorial divided by R factorial times N minus R factorial. [point to first equation]. This equation\* includes a factorial symbol (indicated by an exclamation point). This factorial symbol means\* multiply the number before the exclamation mark times the number minus one, then times the number minus two, and so on down to 1 [point at second equation]. For example\*, 5 factorial equals 5 times 4 times 3 times 2 times 1, which equals 120. (slide 13).\*

Now, let’s finish finding the \*number of combinations that can occur for\* 2 successes in 5 trials. So, 5 factorial is equal to 120, which we just found out. Then, we divided that by 2 factorial (which is 2 times 1) times 5-2 factorial, or 3 factorial (which is 3 times 2 times 1).\* That gives us 120 divided by 12, which equals \*10. This means there are 10 ways to get 2 successes in 5 trials. (slide 14)

Now you see how to compute the\* joint probability of a particular sequence that has R successes in N trials (such as failure, failure, success, failure, success) [point to joint probability equation] and\* how to compute the number of combinations in which a sequence has R successes in N trials (such as 10 ways to get 2 successes out of 5 trials) [point to combination equation]. (slide 15)

As the final step in computing\* binomial probability you just put those two parts together. You can figure out \*the probability of getting R successes out of N trials by multiplying the\* number of combinations for a sequence that has R successes out N trials by\* the joint probability of any one of those sequences. When you do this, you are finding the probability of R successes in N trials. So, if you put that all together you get the formula on the screen [point to equation]. This is what we call a binomial probability. (slide 16)

\*Let’s do an example to see how well our formula for binomial probability works. Suppose I want to find the probability of rolling a die\* 5 times and having 5 or 6 come up exactly 2 times. In this case, we want to know the binomial probability of 2 successes in 5 trials, when the probability of success is 1/3. The\* binomial probability equals the\* number of combinations that have 2 successes in 5 trials times\* the joint probability of this sequence. [point to equation]

\*The number of combinations is 5 factorial divided by 2 factorial times 3 factorial, which equals 5 times 4 times 3 times 2 times 1 divided by 2 times 1 times 3 times 2 times 1 which equals 120 divided by 12 which is\* 10.

The joint probability of any one sequence\* is one-third times one-third times two-thirds times two-thirds times two-thirds, which equals\* 8 divided by 243.

To multiply the number of combinations times the joint probability of a sequence,\* we get 10 times 8 divided by 243 which equals\* 80 divided by 243 (or about .33).

This means you have about a one-third chance of rolling a die 5 times and getting 5 or 6 to come up exactly 2 times. (slide 17)\*

Now you know how to determine the probability of R successes out of N trials when the probability of success is P.