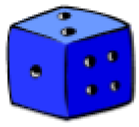
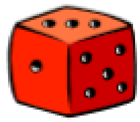
Level 2 Simulation Workbook



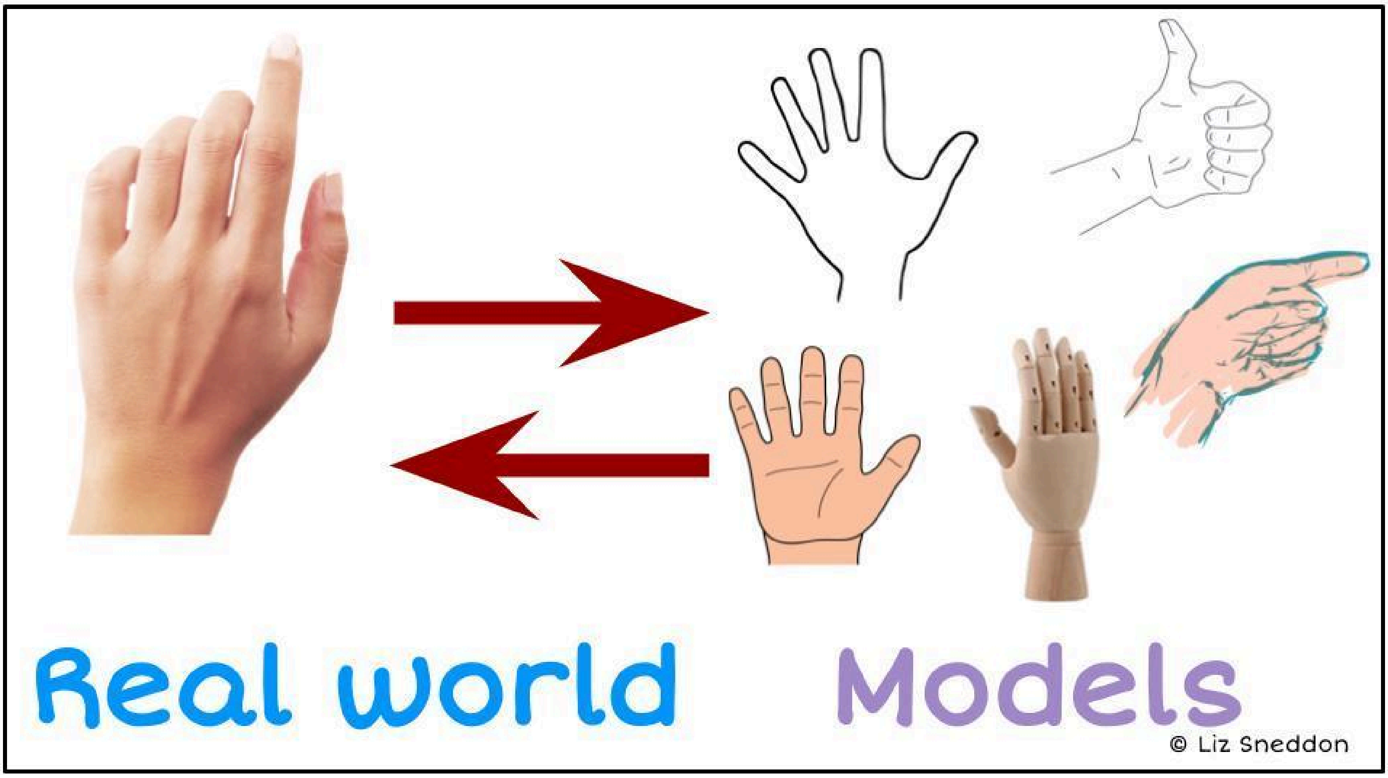


Name:

Written by Liz Sneddon

What is Simulation?

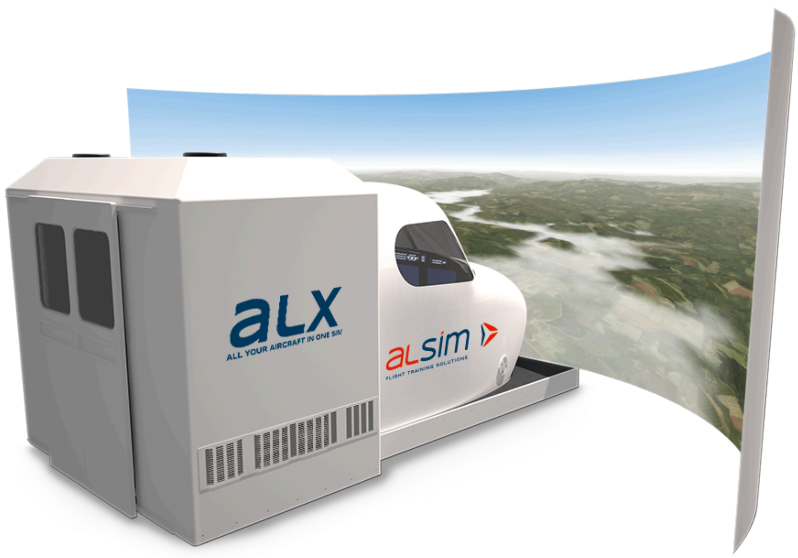
Simulation is the imitation of the operation of a real-world process or system over time.



There are many things that we cannot calculate the theoretical probability for. For example, what is the probability that the photocopier is going to jam today? We can collect data to give us an idea of what the probability might be, and then we can use this data to run a simulation to come up with a more accurate prediction.

Think of a flight simulator for example:

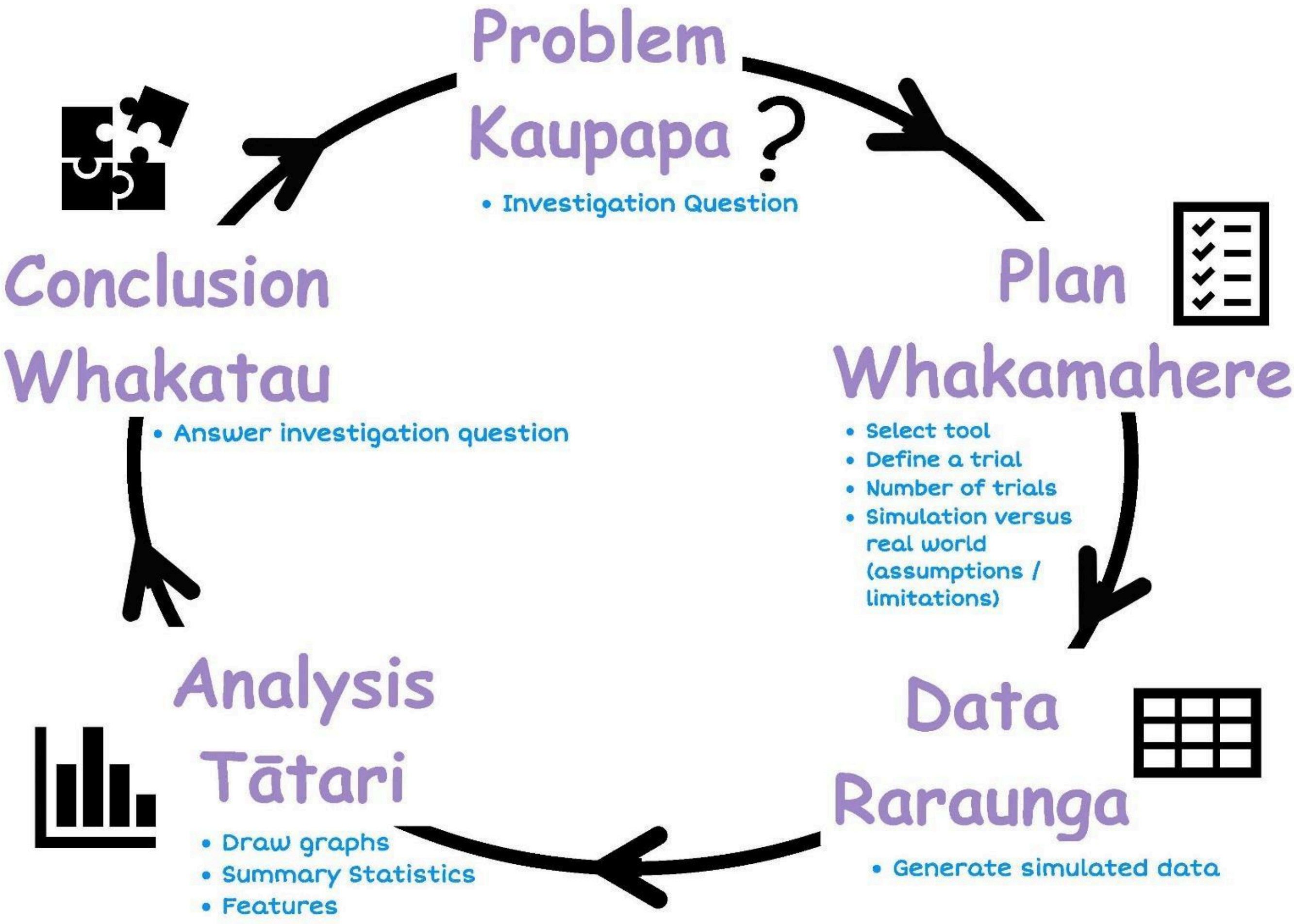
We don't want to put trainee pilots into a real airplane to learn to fly, so instead they put them in a simulator, where they practice again and again and again with a computer model before they go up in a real aircraft.



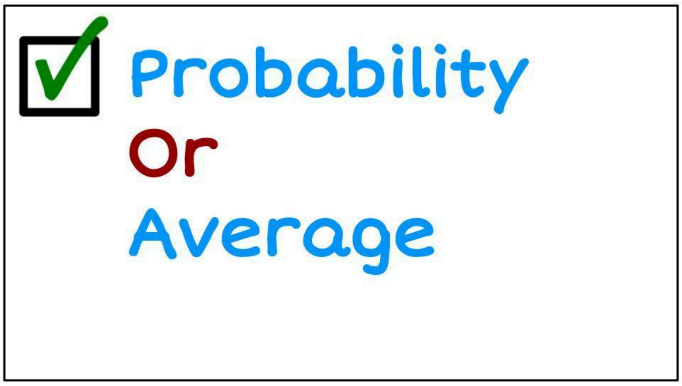
This is a little like what we are going to do for this assessment. We are going to be given a situation, and then design a simulation for that situation. We will then run the simulation and evaluate how good the simulation design was.

PPDAC Investigation cycle

To investigate simulations, we will use the PPDAC cycle:



Problem / Kaupapa



We start with a real-world problem, and we then build a simulation model to better understand and estimate what is happening.

There are two types of investigation questions that you could be asked to investigate.

- The **probability** that an event occurs, or
- The **mean / average number of times** that an event occurs.

The investigation question will be given to you as part of the description of the situation you need to simulate.

Example:

Situation	Mrs Sneddon is interested in the different eye colours that any potential children may have. The probability of any one child having blue eyes is 0.7.
Probability question	If Mrs Sneddon has 4 children, what is the probability that 3 of her children have blue eyes?
Mean/Average question	What is the average number of children Mrs Sneddon has to have before she has two children in a row (one after the other) that have blue eyes?

Exercise 1:

1)

Situation	When playing basketball and doing a penalty shootout, the player gets 3 shots at goal.
Probability question	
Mean/Average question	

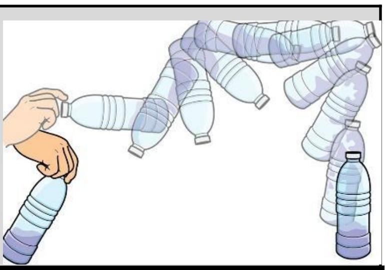
2)

Situation	Mrs Sneddon has a kete (basket) with highlighters for students to use, including kōhai (yellow), kākāriki (green), Kikorangi (blue) and māwhero (pink).
Probability question	
Mean/Average question	

3)

Situation	Apps will often send out notifications when a new message or post is made. Explore notifications received in a one-hour time period.
Probability question	
Mean/Average question	

4)

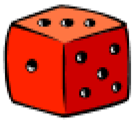
Situation	Doing a bottle flip challenge where each person tries to flip a bottle 5 times to see how often it lands standing up. 
Probability question	
Mean/Average question	

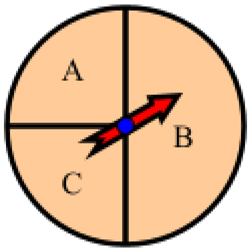
Plan / Whakamahere

Decide what tool to use

You have several tools that you can use to simulate probabilities. They include:

- Coin (gives a 0.5 chance of success)
- Die (gives a 1/6 chance of success)
- Spinner (probability depends on how many sections there are)
- Calculator (can match **ANY** probability)



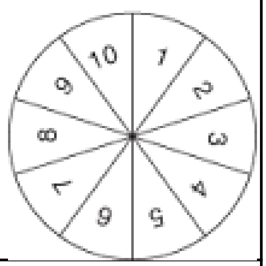


The key step is to match the probability of the example to the tool. Remember that probabilities can be written as a decimal, fraction, or percentage.

Example:

I want to simulate a 70% (or 0.7) chance of getting rain today.

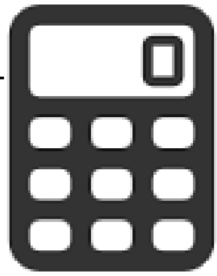
Option 1:

Tool	Spinner with 10 equal categories 
Description	• the numbers 1, 2, 3, 4, 5, 6, 7 match rain occurring, • the numbers 8, 9, 10 match no rain.

Option 2:

Tool	Calculator

Description	generate random numbers between 1- 10 • where the numbers 1 to 7 match rain occurring, • the numbers 8 – 10 match no rain.



Exercise 2:

For each situation below, decide which tools you can use to simulate the situation, and describe how you will match the probability.

1) The chance of eating a healthy lunch today is 0.2

Tool	
Description	

2) The probability of missing the bus today is 1/3

Tool	
Description	

3) The probability of completing homework tonight is 0.5

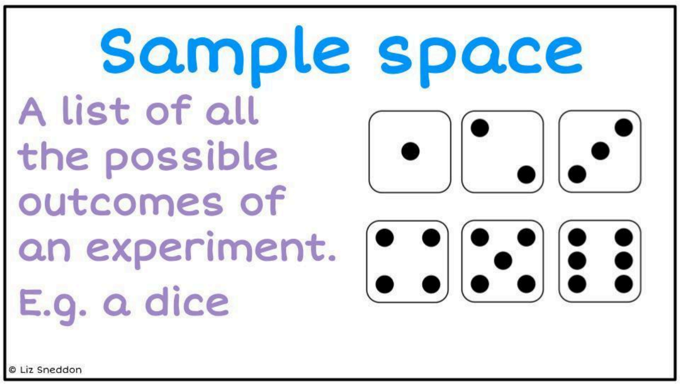
Tool	
Description	

Decide allocation of random numbers to probabilities and outcomes

You must know what the sample space is (all possible outcomes).

Each outcome (e.g., blue eyes) has a single probability associated with it.

All probabilities must add up to 1.



Example

Rolling a die

Outcomes	1, 2, 3, 4, 5, 6

Exercise 3:

List the outcomes for the following situations:

1) The weather today:

Outcomes	

2) Eye colour:

Outcomes	

Match random numbers to outcomes

Say you have 10 random numbers, between 1 and 10, you now want to match these random numbers and outcomes to the **probability** of each outcome.

If the probability that you are simulating is to **one decimal place** (e.g., 0.2), then generate **10 random numbers** and allocate these to the outcomes.

If the probability that you are simulating is to **two decimal places** (e.g., 0.45), then generate **100 random numbers** and allocate these to the outcomes.

Example:

Probability of blue eyes = 0.7.

Because the probability is to one decimal place, I want to generate 10 random numbers between 1 and 10 and allocate them.

To match to blue eyes, I want 7 random numbers, because $\frac{7}{10} = 0.7$.

Allocation:

1, 2, 3, 4, 5, 6, 7 – these numbers match to having blue eyes, and

8, 9, 10 – these numbers match to **not** having blue eyes.

Full Example

The probability of a child being born with blue eyes is 0.3, being born with brown eyes is 0.4, being born with green eyes is 0.2, and being born with grey eyes is 0.1.

Decide the allocation of random numbers to the probabilities and outcomes. Then describe the allocations.

Outcomes	blue eyes, brown eyes, green eyes, or grey eyes. Notice that the probabilities all add up to 1. $(0.3 + 0.4 + 0.2 + 0.1 = 1)$
Tool	Use Excel to generate random numbers between 1 and 10 1, 2, 3, 4, 5, 6, 7, 8, 9, 10
Description	The numbers 1, 2 and 3 represent a child having blue eyes, because there are three outcomes, which matches the probability of blue eyes of $\frac{3}{10} = 0.3$ The numbers 4, 5, 6 and 7 represent a child having brown eyes, because there are four outcomes, which matches the probability of brown eyes of $\frac{4}{10} = 0.4$ The numbers 8 and 9 represent a child having green eyes, because there are two outcomes, which matches the probability of green eyes of $\frac{2}{10} = 0.2$ The number 10 represents a child having grey eyes, because there is one outcome, which matches the probability of grey eyes of $\frac{1}{10} = 0.1$

Putting this altogether:

Outcome	Blue eyes	Brown eyes	Green eyes	Grey eyes
Probability	0.3	0.4	0.2	0.1
Random number matching	1, 2, 3	4, 5, 6, 7	8, 9	10

Exercise 4:

Decide the allocation of random numbers to the probabilities and outcomes for each of the following situations.

1) A family was going to the pet store to choose 6 pets. The probability that they would choose a dog is 0.4, the probability that they would choose a cat is 0.3, the probability that they would choose a fish is 0.2, and the probability that they would choose a bird is 0.1.

Outcome				
Probability				
Random number matching				

Description:

2) For each assessment this year, Julie thinks she has a 32% chance of getting Not Achieved, a 48% chance of getting Achieved, a 17% chance of getting a Merit,

and the remainder is the chance of her getting an Excellence grade. Julie wants to get at least one Excellence and one Merit this year.

Outcome				
Probability				
Random number matching				

Description:

RANDBETWEEN formula

Calculators and computers can generate random numbers. The RANDBETWEEN formula will generate a random (whole number) between two values.

= RANDBETWEEN (Minimum, Maximum)

Example

I want to generate random numbers between 1 and 10.

Formula: =RANDBETWEEN(1,10)

Exercise 5:

Open a new spreadsheet in Excel.

1) Type in the formula: **=RANDBETWEEN(1,10)**

Write down the random number you generated	

2) In the next cell, type in the formula: **=RANDBETWEEN(1,100)**

Write down the random number you generated	

3) Generate 10 random numbers between 4 and 20.

Equation	
Write down the random numbers you generated	

4) Generate 10 random numbers between 1 and 100.

Equation	
Write down the random numbers you generated	

Interpreting random numbers

For each situation, once we have generated random numbers, we need to match this back to the outcome that it represents.

Example

Here is the random number allocation table for the colour of a child's eyes:

Outcome	**Blue eyes**	**Brown eyes**	**Green eyes**	**Grey eyes**
Probability	0.3	0.4	0.2	0.1
Random number matching	1, 2, 3	4, 5, 6, 7	8, 9	10

Using the formula "=RANDBETWEEN(1,10) I generated the following random numbers:

3, 4, 4, 7, 5, 9, 1, 4, 8

What do these random numbers represent?

Each number represents the colour of another child's eyes. So, I match up the first number 3 to the outcome, and this represents a child with blue eyes. I do the same now for all the random numbers:

3, 4, 4, 7, 5, 9, 1, 4, 8

Blue, Brown, Brown, Brown, Brown, Green, Blue, Brown, Green

Therefore, there would be 9 children, of which 5 had Brown eyes, 2 had Blue eyes, and 2 had Green eyes.

Exercise 6:

Write the equations, generate 10 random numbers, and explain what they represent for the following situations.

1) A family was going to the pet store to choose a pet. The probability that they would choose a dog is 0.4, the probability that they would choose a cat is 0.3, the probability that they would choose a fish is 0.2, and the probability that they would choose a bird is 0.1.

Equation	

Outcome	**Dog**	**Cat**	**Fish**	**Bird**
Probability	0.4	0.3	0.2	0.1
Random number matching				

Random number	**What it represents**

2) For each assessment this year, Julie thinks she has a 32% chance of getting Not Achieved, a 48% chance of getting Achieved, a 17% chance of getting a Merit, and the remainder is the chance of her getting an Excellence grade.

Equation	

Outcome	**Not Achieved**	**Achieved**	**Merit**	**Excellence**
Probability				
Random number matching				

Random number	**What it represents**

Describe a trial, including the finishing point

We need to combine the previous skills together: Tool, Allocation of random number to outcomes and probabilities, Equation for generating random numbers, and deciding the number of trials **(50)**.

Trial

A single run through of an experiment.

E.g. a roll of the dice

Example 1:

The probability of a tamariki/child being born with blue eyes is 0.3, being born with brown eyes is 0.4, being born with green eyes is 0.2, and being born with grey eyes is 0.1.

A married couple are planning to keep having children **until they have all four different coloured eyes in their family**.

Outcome	Blue eyes	Brown eyes	Green eyes	Grey eyes
Probability	0.3	0.4	0.2	0.1
Random number matching	1, 2, 3	4, 5, 6, 7	8, 9	10

Tool	random number generator in Excel
Equation	=RANDBETWEEN(1,10)
Number of trials	50
Description	We want to run a simulation, with 50 trials, generating random numbers in each trial. **One trial consists of** generating random numbers until we have one of each of the 4 outcomes (Blue eyes, Brown eyes, Green eyes and Grey eyes). This means that in each trial, I will keep generating random numbers until I have one of each eye colour. Then I will move on to the next trial, and in total I will generate 50 trials.

Example 2:

The probability of a tamariki/child being born with blue eyes is 0.3, being born with brown eyes is 0.4, being born with green eyes is 0.2, and being born with grey eyes is 0.1.

A married couple are planning to have a maximum of 6 children but would stop having children if they got all four eye colours.

Outcome	**Blue eyes**	**Brown eyes**	**Green eyes**	**Grey eyes**
Probability	0.3	0.4	0.2	0.1
Random number matching	1, 2, 3	4, 5, 6, 7	8, 9	10

Tool	random number generator in Excel
Equation	=RANDBETWEEN(1,10)
Number of trials	50
Description	We want to run a simulation, with 50 trials, generating random numbers in each trial. **One trial consists of** generating random numbers until we have one of each of the 4 outcomes (Blue eyes, Brown eyes, Green eyes and Grey eyes) **OR until they have six children**. This means that in each trial, I will keep generating random numbers until I have one of each eye colour, up to a maximum of 6 random numbers. Then I will move on to the next trial, and in total I will generate 50 trials.

Exercise 7:

Write a full plan for each of the following situations:

1) There are three common PE games that teachers can use if the weather is wet. On a wet day there is a 10% chance that a teacher will choose to play table tennis, a 50% chance to play basketball, or a 40% chance to play volleyball. We want to investigate the chance of a class playing all three games over 5 wet days.

Outcome			
Probability			
Random number matching			

Tool	
Equation	
Number of trials	
Description	

2) Mrs Sneddon has a kete (basket) with highlighters for students to use, including 14 kōhai (yellow), 18 kākāriki (green), 6 kikorangi (blue) and 2 māwhero (pink). Mrs Sneddon wants to investigate getting all four colours of highlighters out when she selects up to 10 highlighters at random.

Outcome				
Probability				
Random number matching				

Tool	
Equation	
Number of trials	
Description	

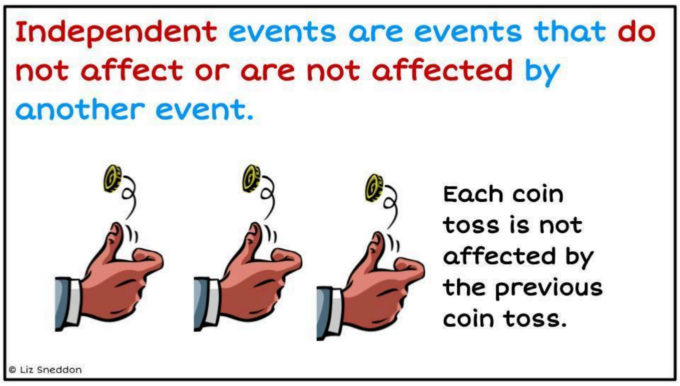
3) Screwdrivers often come in a set of 5, all different sizes and head shapes. When building a set of shelves there is a 38% chance of needing to use the large slot head, a 22% of needing to use the large Phillips head, a 14% chance of needing to use the square head, a 15% chance of needing to use the small slot head, and an 11% chance of needing to use the small Phillips head screwdriver. You need to investigate the chance of needing to use all five of the different screwdrivers when building the shelves, which have 12 screws.

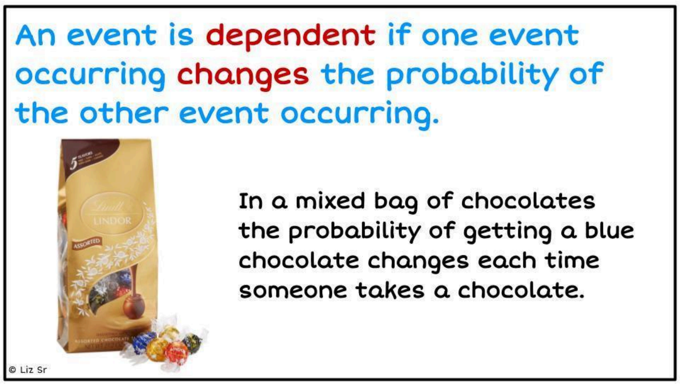
Outcome				
Probability				
Random number matching				

Tool	
Equation	
Number of trials	
Description	

Assumptions

There are many things that we have to assume in order for the conclusion of the simulation to be valid and reliable. One assumption is about events being independent.





Example:

For our example of the four different coloured eyes in the children of a married couple, we are **assuming** that the **eye colour of each child is independent** (and not connected in any way) to the eye colour of another child.

However, if we think about what role genetics play in determining eye colour, the eye colour of the parents is critical in determining what eye colour the children can possibly have.

For example, if both parents have blue eyes, then as this is a recessive characteristic, the ONLY possible eye colour that their children can have is blue.

Exercise 8:

Decide whether or not it is valid to assume independence for each, justifying and explaining why or why not.

1)

Scenario	There are three common PE games that teachers can use if the weather is wet. On a wet day there is a 10% chance that a teacher will choose to play table tennis, a 50% chance to play basketball, or a 40% chance to play volleyball. We want to investigate the chance of a class playing all three games over 5 wet days.

Independence Assumption	

2)

Scenario	Mrs Sneddon has a kete (basket) with highlighters for students to use, including 14 kōhai (yellow), 18 kākāriki (green), 6 kikorangi (blue) and 2 māwhero (pink). Mrs Sneddon wants to investigate getting all four colours of highlighters out when she selects up to 10 highlighters at random. 

Independence Assumption	

3)

Scenario	Screwdrivers often come in a set of 5, all different sizes and head shapes. When building a set of shelves there is a 38% chance of needing to use the large slot head, a 22% of needing to use the large Phillips head, a 14% chance of needing to use the square head, a 15% chance of needing to use the small slot head, and an 11% chance of needing to use the small Phillips head screwdriver. You need to investigate the chance of needing to use all five of the different screwdrivers when building the shelves, which have 12 screws. 

Independence Assumption	

There are many other assumptions that you can discuss in every simulation. Many of these assumptions apply specifically to the context or situation.

Some common ideas to think about are:

- Is the probability of each outcome going to remain constant throughout the situation? For example, is the chance of rain today likely to be the same as the chance of rain tomorrow?
- What are some limitations of your model when compared to the real-world problem?
- Other factors that may affect the probability of each outcome.
- etc

Example 1:

For our example of the four different coloured eyes in the children of a married couple, we are assuming that the eye colour of each child is independent (and not connected in any way) to the eye colour of another child.

One assumption made here is that the probability of each eye colour remains constant for each child that they have. This assumption may be reasonable as each child will have a mix of genetics inherited from each parent.

A second assumption about the children's eye colour remaining independent may not hold true if any of the children were to be identical twins or triplets for example. In this case, these identical siblings would not be independent in their eye colour.

A third assumption may be that all other factors in their lifestyle, that may affect the genetic selection of eye colour, remain constant. For example, we assume that the food that they eat remains similar for each pregnancy, and that the food a person eats has no effect on the eye colour of a child during pregnancy.

Example 2:

Situation: Mrs Sneddon wants to explore how many good night's sleep she gets each week.

Assumptions:

I assume that having a good sleep one night is independent of the next night. But if Mrs Sneddon gets sick with the flu for example, then she is more likely to not have a good night's sleep, or if it is the school holidays or weekends, she might be more likely to have a good night's sleep.

Other factors:

One factor that might affect whether Mrs Sneddon gets a good night sleep is how old her children are. For example, if her children are very young and wake up during the night, she isn't likely to have a good night's sleep. Whereas if her children are older, she is more likely to have a good night's sleep.

Another factor that may affect having a good night's sleep, is whether Mrs Sneddon spends these nights sleeping in her normal bed, or whether she goes on holiday or stays with family and sleeps in another bed with a different mattress. The other bed could be more or less comfortable, leading to having a better or worse night's sleep.

Also, depending on Mrs Sneddon's job or other potential stressors in her life (e.g., sick parents, etc.), this may affect whether she has a good night's sleep or not.

Exercise 9:

Discuss what assumptions, limitations or other factors may exist for each of the following situations.

1)

Situation	There are three common PE games that teachers can use if the weather is wet. On a wet day there is a 10% chance that a teacher will choose to play table tennis, a 50% chance to play basketball, or a 40% chance to play volleyball. We want to investigate the chance of a class playing all three games over 5 wet days.
Assumptions and other factors	

2)

Situation	Mrs Sneddon has a kete (basket) with highlighters for students to use, including 14 kōhai (yellow), 18 kākāriki (green), 6 kikorangi (blue) and 2 māwhero (pink). Mrs Sneddon wants to investigate getting all four colours of highlighters out when she selects up to 10 highlighters at random.
Assumptions and other factors	

3)

Situation	Screwdrivers often come in a set of 5, all different sizes and head shapes. When building a set of shelves there is a 38% chance of needing to use the large slot head, a 22% of needing to use the large Phillips head, a 14% chance of needing to use the square head, a 15% chance of needing to use the small slot head, and an 11% chance of needing to use the small Phillips head screwdriver. You need to investigate the chance of needing to use all five of the different screwdrivers when building the shelves, which have 12 screws.
Assumptions and other factors	

Effect of the assumptions on the simulation

If any of the assumptions we discussed were not upheld (i.e., they were false), then we need to think how this would affect the validity and reliability of our simulation, the analysis and conclusion.

Example:

An analogy for you. If the house that you lived in was built on a shaky foundation, would you trust that house to hold up in every storm?

The answer of no is the same that applies to simulation. If the assumptions that our model is based upon are shaky, then the model itself will be shaky, and therefore the results and conclusions will be shaky.

If there is only a small crack in the foundation of your house, then there is still a good chance that the house will hold up. Similarly with our model. If one of the assumptions has only got a small effect, then the model will still hold up most of the time.

If however there is a large crack, then it is likely the house will fall down. Similarly with our model. If one of the assumptions is very likely to be false, then the model, the results and the conclusion are all likely to fall over and be wrong too.

Exercise 10:

Think about the assumptions you discussed for each of the following situations. Write a discussion for each about how this may or may not affect your conclusion.

1)

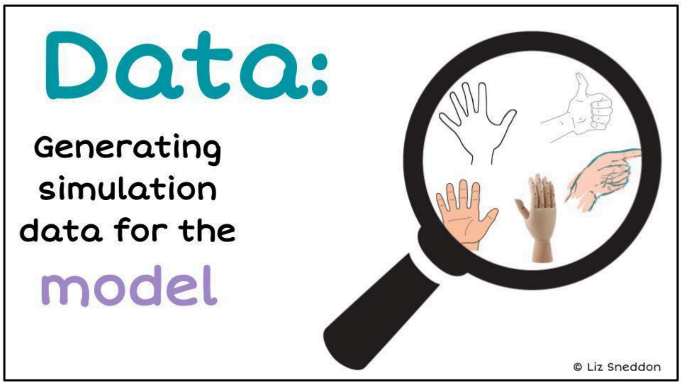
Situation	There are three common PE games that teachers can use if the weather is wet. On a wet day there is a 10% chance that a teacher will choose to play table tennis, a 50% chance to play basketball, or a 40% chance to play volleyball. We want to investigate the chance of a class playing all three games over 5 wet days.
Effect of assumptions on your conclusion	

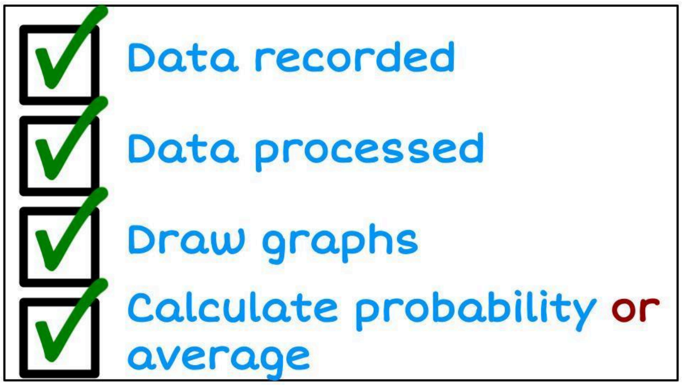
2)

Situation	Mrs Sneddon has a kete (basket) with highlighters for students to use, including 14 kōhai (yellow), 18 kākāriki (green), 6 kikorangi (blue) and 2 māwhero (pink). Mrs Sneddon wants to investigate getting all four colours of highlighters out when she selects up to 10 highlighters at random.
Effect of assumptions on your conclusion	

3)

Situation	Screwdrivers often come in a set of 5, all different sizes and head shapes. When building a set of shelves there is a 38% chance of needing to use the large slot head, a 22% of needing to use the large Phillips head, a 14% chance of needing to use the square head, a 15% chance of needing to use the small slot head, and an 11% chance of needing to use the small Phillips head screwdriver. You need to investigate the chance of needing to use all five of the different screwdrivers when building the shelves, which have 12 screws.
Effect of assumptions on your conclusion	





Once you have your plan, the next step is to generate data. We want to be able to do this using Excel (or Google Sheets) on our computer.

In the assessment, our results have to be recorded in sufficient detail that your teacher can check the accuracy of the solution. This means you need to record which random numbers you generate, and how many numbers you generate in each trial.

Remember your number of trials is at least 50, so you will need at least 50 rows to record the data.

Example 1:

Trial	**1st simulation**	**2nd simulation**	**3rd simulation**	**...**	**Frequency**	**Complete?**
1						
2						
3						
...						
50						

Example 2:

Situation:	The probability of a tamariki/child being born with blue eyes is 0.3, being born with brown eyes is 0.4, being born with green eyes is 0.2, and being born with grey eyes is 0.1. A married couple are planning to have a maximum of 6 children but would stop having children if they got all four eye colours.

Data

Trial	Child 1	Child 2	Child 3	Child 4	Child 5	Child 6	Frequency	Complete?
1								
2								
...								
50								

Do the simulation and record the results

Feel free to watch the video with an example of how-to setup your Excel spreadsheet before trying the exercises for yourself.

Here are the steps involved to setup the first column:

<table>
<tr>
<td>

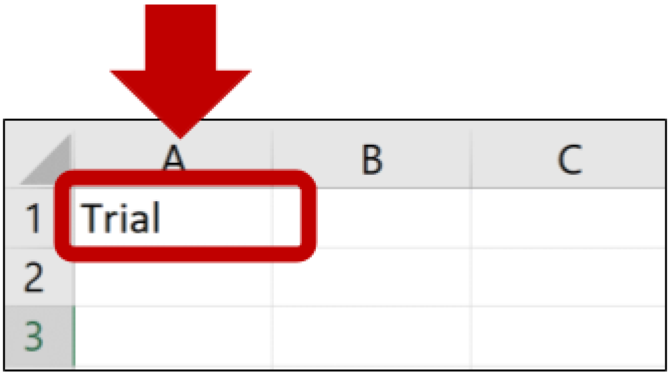
Step 1:

Open up Excel on your laptop and open a blank document.

</td>
<td>

Step 2:

Label the first column **Trial**



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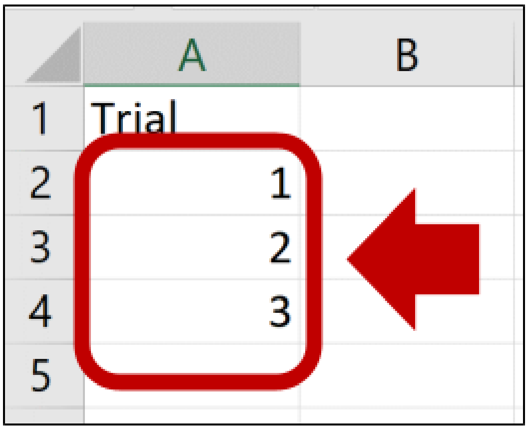
Step 3:

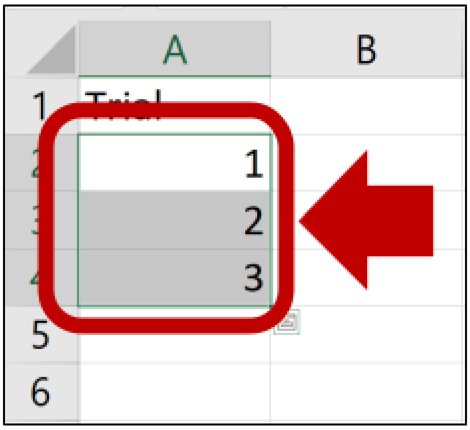
In column A, we want to enter the numbers between 1 and 50 (the number of trials we want to do). Excel can recognise patterns, so type the numbers 1, 2 and 3 into the next 3 rows.



</td>
<td>

Step 4:

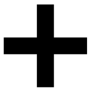
Next, select these cells with the numbers 1, 2 and 3.

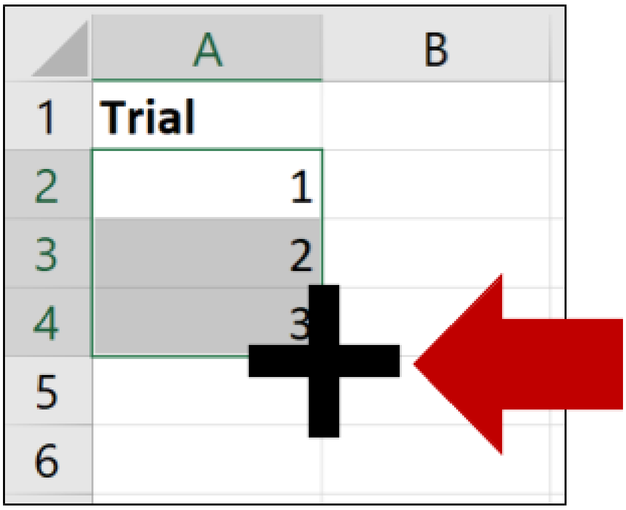


</td>
</tr>
</table>

Step 5:

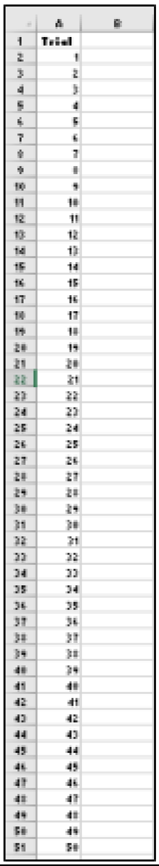
Move your mouse to the bottom right-hand corner of these selected cells,

and a  symbol will appear.



Step 6:

Click and hold your mouse button, and drag it down until the 51st row, and Excel will fill in the numbers up until 50.



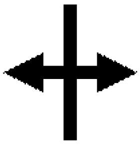
Excel Tip to resize the width of the columns

Step 1:

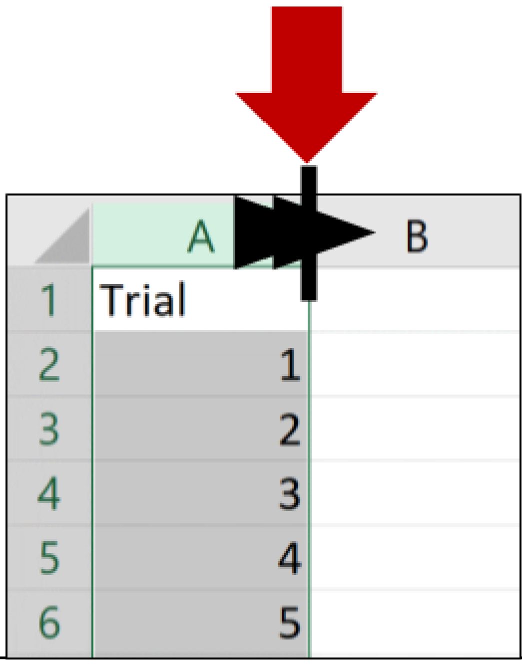
We can get Excel to automatically resize the width of the columns. Select the columns you want to resize, in this case, select columns A and B by going to the letter A, click and hold, and move the mouse across to the letter B. Then let go of the mouse button.

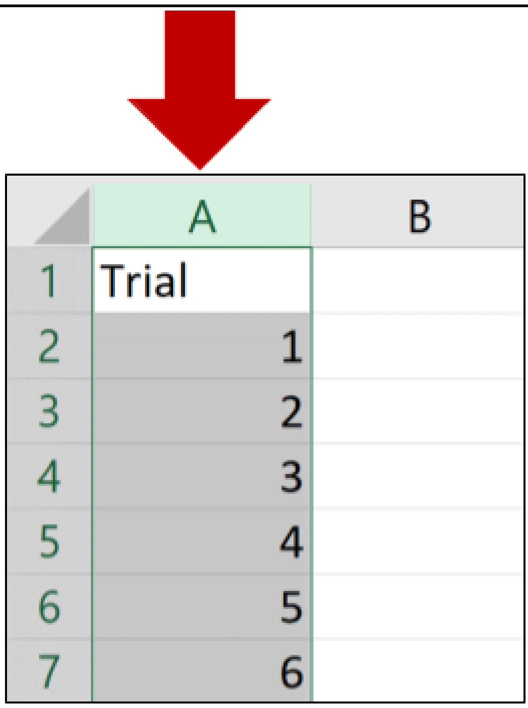
Step 2:

Move your mouse to be on the line between column A and column B, and a



symbol will appear. Double click on this symbol and the columns will automatically resize to the right width.

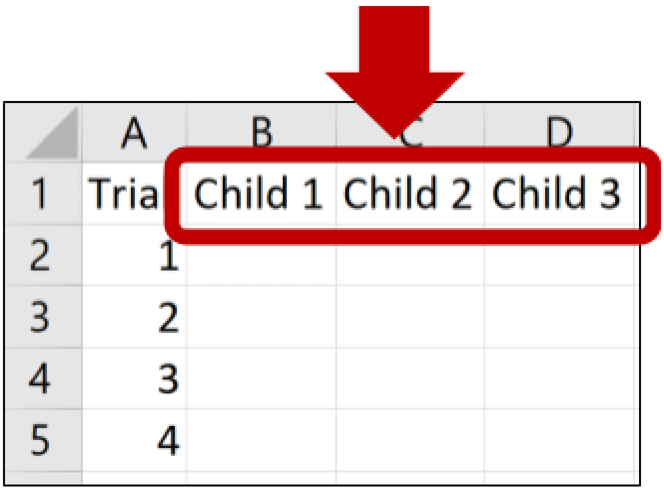




Here are the steps involved to setup the outcome columns:

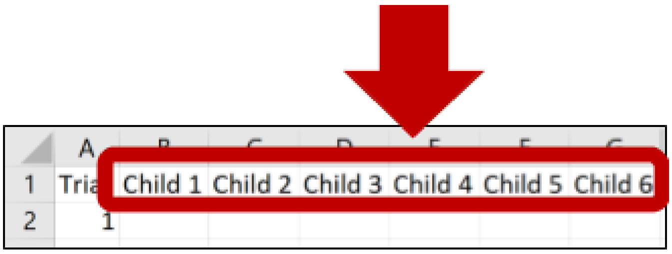
Step 1:

Label the second column by the object you are simulating (e.g., a child). Then label the third column and fourth columns, adding the number 1, 2 and 3 beside each object.



Step 2:

Select these cells that you have labelled and copy the pattern sideways. Look back at your problem to see how many you need to generate (e.g., 6 children maximum).



Step 3:

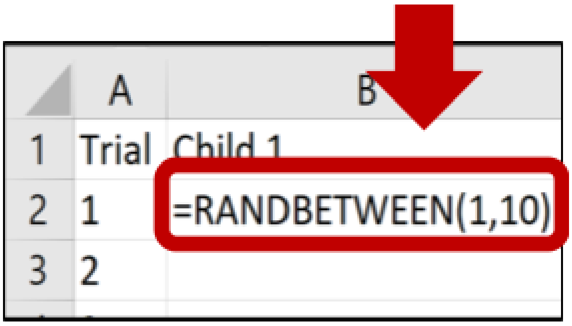
Now add a column labelled **Frequency**, and another column labelled **Complete?**

H	I
Frequency	Complete?

The next step is to use the RANDBETWEEN formula to generate simulation data

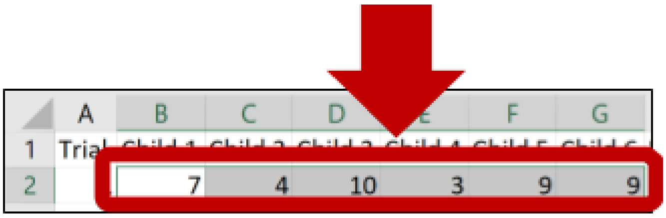
Step 1:

Type your equation into the first cell.



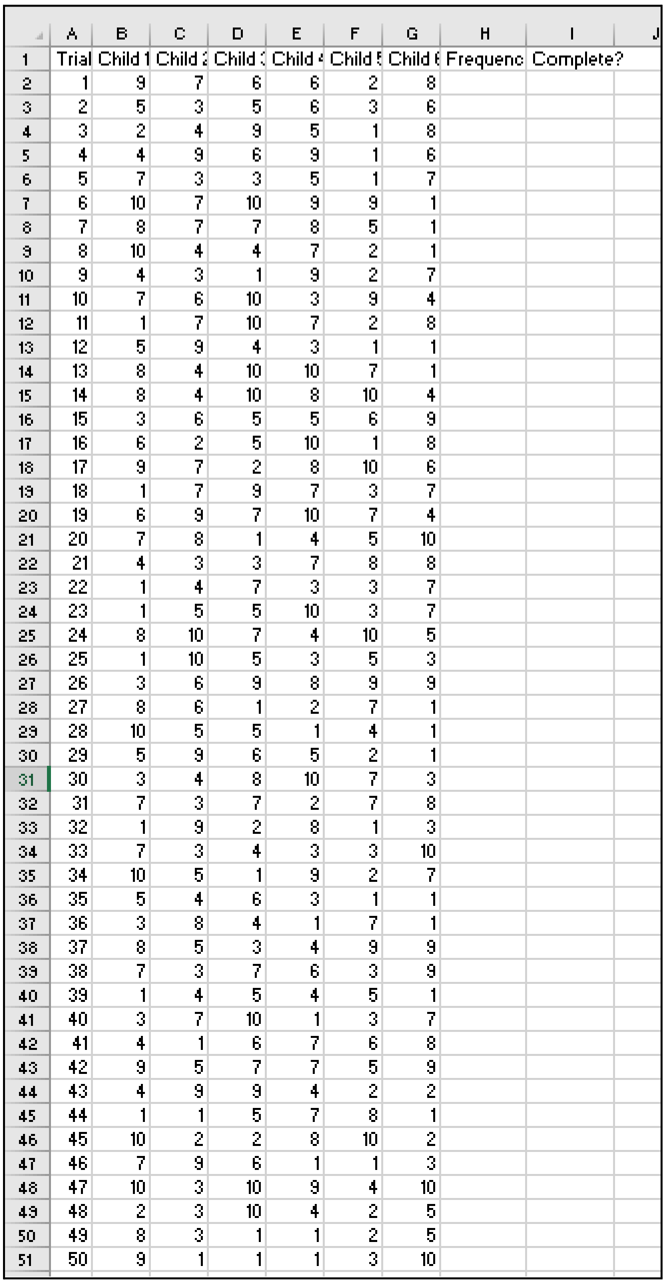
Step 2:

Copy the formula across for all the outcomes (e.g., up to Child 6)



Step 3:

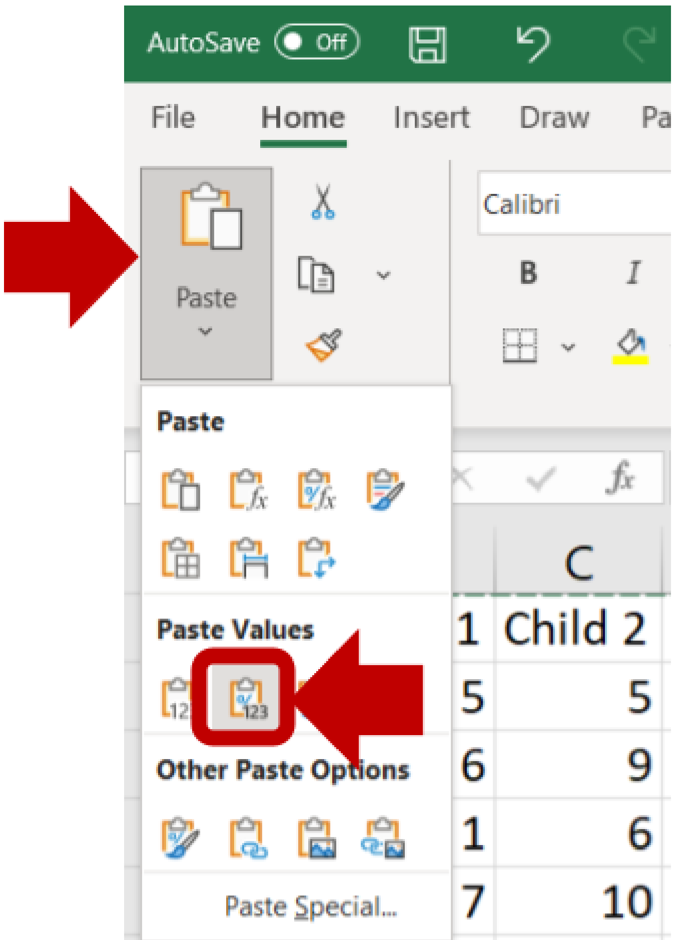
Copy the formula all the way down for the 50 trials and this will generate all your data.



	A	B	C	D	E	F	G	H	I
1	Trial	Child 1	Child 2	Child 3	Child 4	Child 5	Child 6	Frequenc	Complete?
2	1	9	7	6	6	2	8		
3	2	5	3	5	6	3	6		
4	3	2	4	9	5	1	8		
5	4	4	9	6	9	1	6		
6	5	7	3	3	5	1	7		
7	6	10	7	10	9	9	1		
8	7	8	7	7	8	5	1		
9	8	10	4	4	7	2	1		
10	9	4	3	1	9	2	7		
11	10	7	6	10	3	9	4		
12	11	1	7	10	7	2	8		
13	12	5	9	4	3	1	1		
14	13	8	4	10	10	7	1		
15	14	8	4	10	8	10	4		
16	15	3	6	5	5	6	9		
17	16	6	2	5	10	1	8		
18	17	9	7	2	8	10	6		
19	18	1	7	9	7	3	7		
20	19	6	9	7	10	7	4		
21	20	7	8	1	4	5	10		
22	21	4	3	3	7	8	8		
23	22	1	4	7	3	3	7		
24	23	1	5	5	10	3	7		
25	24	8	10	7	4	10	5		
26	25	1	10	5	3	5	3		
27	26	3	6	9	8	9	9		
28	27	8	6	1	2	7	1		
29	28	10	5	5	1	4	1		
30	29	5	9	6	5	2	1		
31	30	3	4	8	10	7	3		
32	31	7	3	7	2	7	8		
33	32	1	9	2	8	1	3		
34	33	7	3	4	3	3	10		
35	34	10	5	1	9	2	7		
36	35	5	4	6	3	1	1		
37	36	3	8	4	1	7	1		
38	37	8	5	3	4	9	9		
39	38	7	3	7	6	3	9		
40	39	1	4	5	4	5	1		
41	40	3	7	10	1	3	7		
42	41	4	1	6	7	6	8		
43	42	9	5	7	7	5	9		
44	43	4	9	9	4	2	2		
45	44	1	1	5	7	8	1		
46	45	10	2	2	8	10	2		
47	46	7	9	6	1	1	3		
48	47	10	3	10	9	4	10		
49	48	2	3	10	4	2	5		
50	49	8	3	1	1	2	5		
51	50	9	1	1	1	3	10		

Step 4:

The computer will keep generating new random numbers every time we type something. We want to use the numbers that we have rather than getting new ones all the time. The best thing to do now, is to **select all your data**, **copy** it, and then click on the **Paste** button and select **Paste Values, Numbers**. This will replace all the formula with the random number that was generated.



In order to make it easier for us to figure out what outcomes we have, it is useful to colour code our data.

Example:

For the different eye colours of tamariki/children, I am going to colour the cells in to match the random number. I need to remind myself of the random allocation table I made:

Outcome	Blue eyes	Brown eyes	Green eyes	Grey eyes
Probability	0.3	0.4	0.2	0.1
Random number matching	1, 2, 3	4, 5, 6, 7	8, 9	10

If I have the numbers 1, 2, or 3, I will colour those cells blue to match blue eyes.

If I have the numbers 4 – 7, I will colour them brown to match brown eyes.

If I have the numbers 8 or 9, I will colour them green to match green eyes.

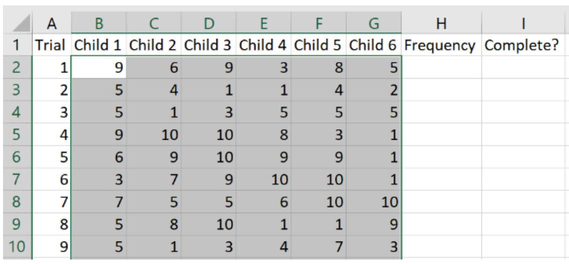
If I have the number 10, I will colour it grey.

Luckily there is a way for us to get the computer to do this colouring quickly for us, otherwise it would take us a long time.

We want to do **Conditional Formatting**. Here are the steps:

Step 1:

Select all the cells you want to colour.



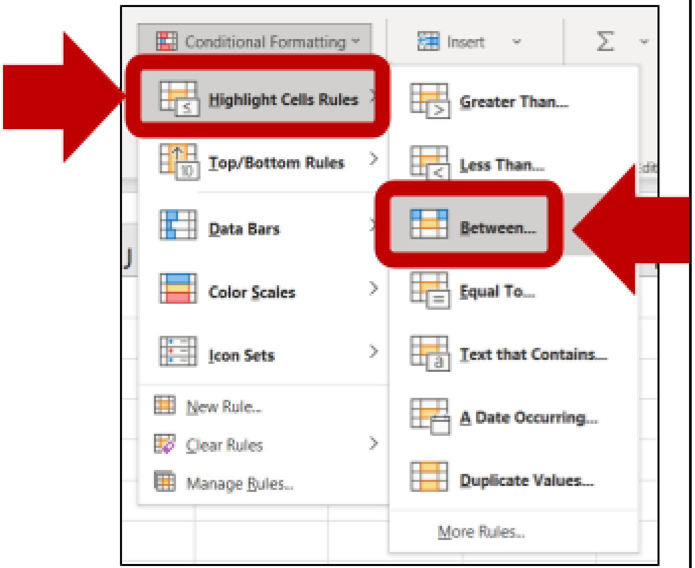
	A	B	C	D	E	F	G	H	I
1	Trial	Child 1	Child 2	Child 3	Child 4	Child 5	Child 6	Frequency	Complete?
2	1	9	6	9	3	8	5		
3	2	5	4	1	1	4	2		
4	3	5	1	3	5	5	5		
5	4	9	10	10	8	3	1		
6	5	6	9	10	9	9	1		
7	6	3	7	9	10	10	1		
8	7	7	5	5	6	10	10		
9	8	5	8	10	1	1	9		
10	9	5	1	3	4	7	3		

Step 2:

On the Toolbar at the top, go to the Styles section, and click on the Conditional Formatting button.

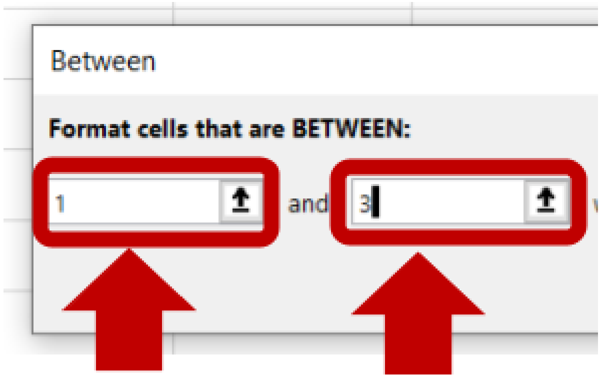
Step 3:

Select the **Highlight Cells Rules** and choose **Between**



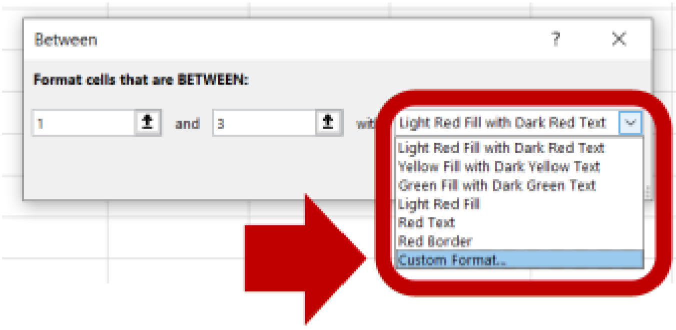
Step 4:

Use your random number allocation table to choose the values, then enter these numbers (e.g., I want the numbers 1 to 3 to be coloured in blue, so I will enter 1 and 3).



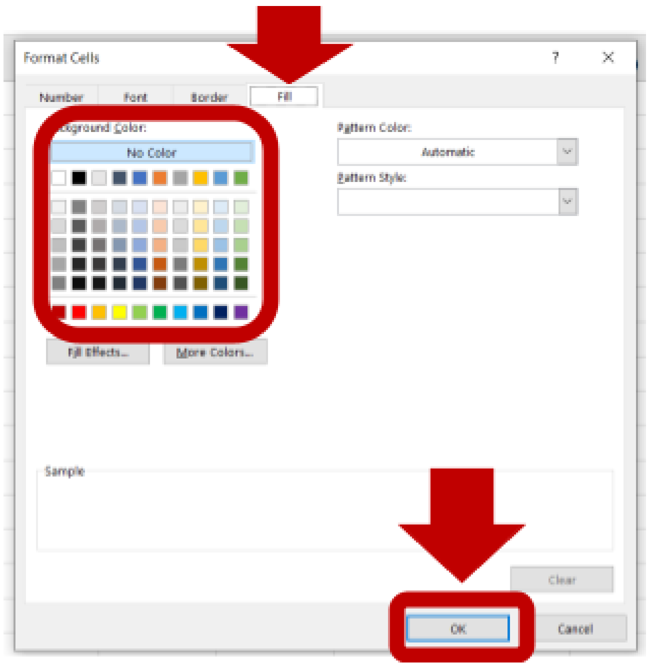
Step 5:

Now we want to select the colour. Click on the list of **Options** and choose **Custom Format**.



Step 6:

Go to the Fill Tab and then select the colour you want. Then press the OK button.



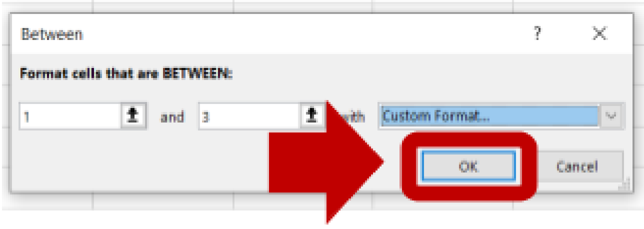
Step 7:

Press the OK button and all the cells with the numbers you choose have been coloured in.

Step 8:

Repeat this with the other colours you need.

	A	B	C	D	E	F	G	H	I
1	Trial	Child 1	Child 2	Child 3	Child 4	Child 5	Child 6	Frequency	Complete?
2	1	9	10	10	4	1	2		
3	2	5	6	3	8	4	7		
4	3	6	10	7	2	8	2		
5	4	7	3	2	10	10	9		



Next it is time to process this data. This is where you need to go back to your definition of what one trial is.

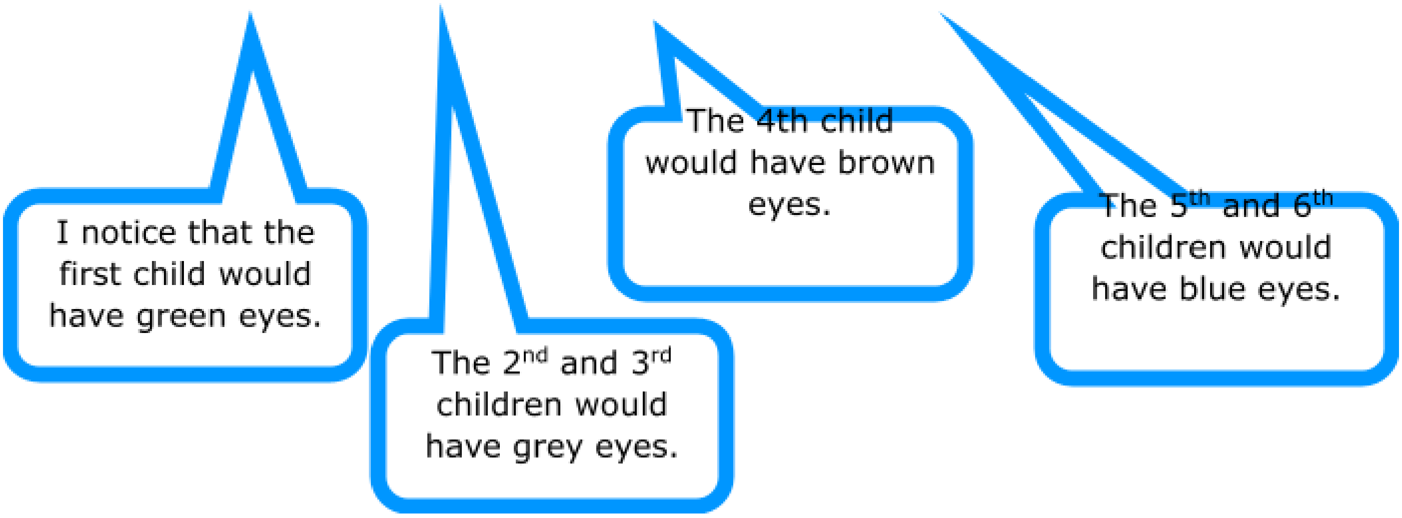
Example:

One trial consists of generating random numbers until we have one of each of the 4 outcomes (Blue eyes, Brown eyes, Green eyes and Grey eyes) **OR** until they have six children.

For the spreadsheet, I now need to look at each Trial and see how many children they would have, and if they get all four eye colours. In the frequency column I will count the number of children (which is either the maximum of 6, or the number of children they had before they got all four eye colours).

Let's have a look at the first trial (the first row):

	A	B	C	D	E	F	G	H	I
1	Trial	Child 1	Child 2	Child 3	Child 4	Child 5	Child 6	Frequency	Complete?
2	1	9	10	10	4	1	2		



The definition of a trial said that the couple would keep having children either till a maximum of 6, or until they had children with 4 different coloured eyes. In this first example, the couple would stop after their 5th child, because they had all four colours by this time.

So, to tidy this up, I will delete the random number in the 6th Child's cell, and write a Frequency of 5, and write Yes under the Complete column.

	A	B	C	D	E	F	G	H	I
1	Trial	Child 1	Child 2	Child 3	Child 4	Child 5	Child 6	Frequency	Complete?
2	1	9	10	10	4	1		5	Yes

Let's now look at the second trial (second row):

	A	B	C	D	E	F	G	H	I
1	Trial	Child 1	Child 2	Child 3	Child 4	Child 5	Child 6	Frequency	Complete?
2	1	9	10	10	4	1		5	Yes
3	2	5	6	3	8	4	7		

The 1st and 2nd child would have brown eyes.

The 3rd child would have blue eyes.

The 4th child would have green eyes.

The 5th and 6th children would have brown eyes.

Here there are only 3 different coloured eyes, brown, blue, and green. So, I will write a frequency of 6 (that was the maximum number of children they would have) and write No under the Complete? column.

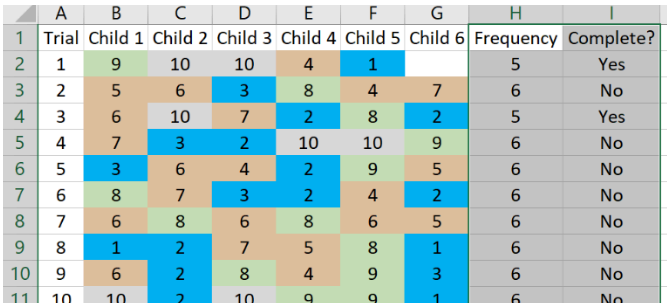
I then carry out and fill in the rest of the trials (all 50 of them).

	A	B	C	D	E	F	G	H	I
1	Trial	Child 1	Child 2	Child 3	Child 4	Child 5	Child 6	Frequency	Complete?
2	1	9	10	10	4	1		5	Yes
3	2	5	6	3	8	4	7	6	No
4	3	6	10	7	2	8	2	5	Yes
5	4	7	3	2	10	10	9	6	No
6	5	3	6	4	2	9	5	6	No
7	6	8	7	3	2	4	2	6	No

The last step is to summarise the data and draw graphs. If you select the last two columns (including the headings **Frequency** and **Complete?**) you can copy and paste this into NZGrapher. Then select a bar graph and summary statistics for each variable.

Step 1:

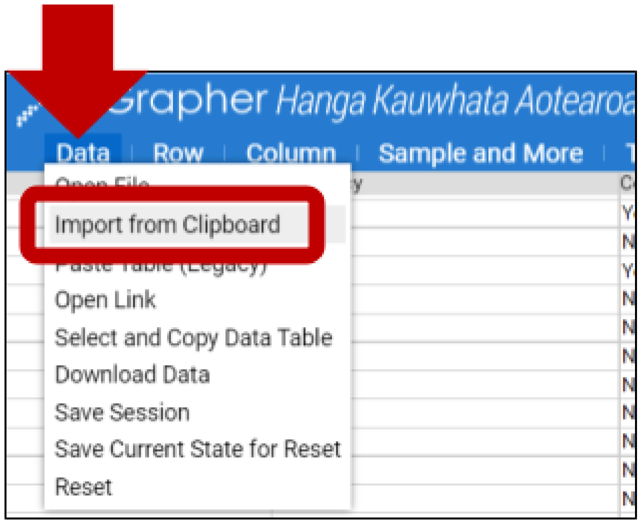
Select all the cells you want to copy (**Frequency** column and **Complete?** column. Copy these cells.



	A	B	C	D	E	F	G	H	I
1	Trial	Child 1	Child 2	Child 3	Child 4	Child 5	Child 6	Frequency	Complete?
2	1	9	10	10	4	1		5	Yes
3	2	5	6	3	8	4	7	6	No
4	3	6	10	7	2	8	2	5	Yes
5	4	7	3	2	10	10	9	6	No
6	5	3	6	4	2	9	5	6	No
7	6	8	7	3	2	4	2	6	No
8	7	6	8	6	8	6	5	6	No
9	8	1	2	7	5	8	1	6	No
10	9	6	2	8	4	9	3	6	No
11	10	10	2	10	9	9	1	6	No

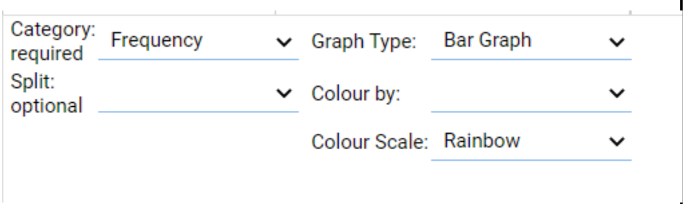
Step 2:

Go to NZGrapher, click on the **File** menu, and select **Import from Clipboard**.



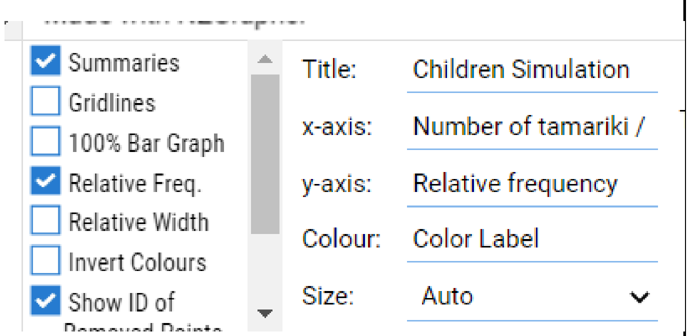
Step 3:

Select a Bar graph and choose the Frequency variable.



Step 4:

Add Summaries and Relative Frequency to the graph, along with axis labels and a title.



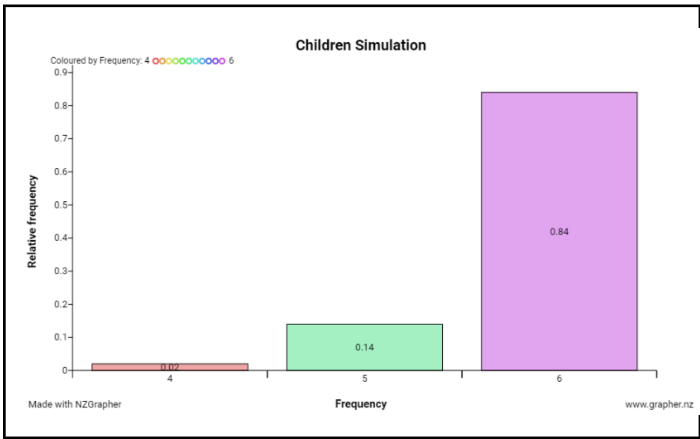
Step 5:

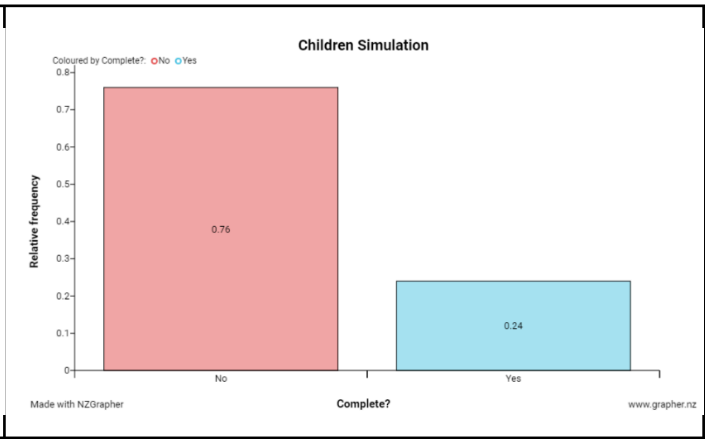
Repeat with the Complete? variable.

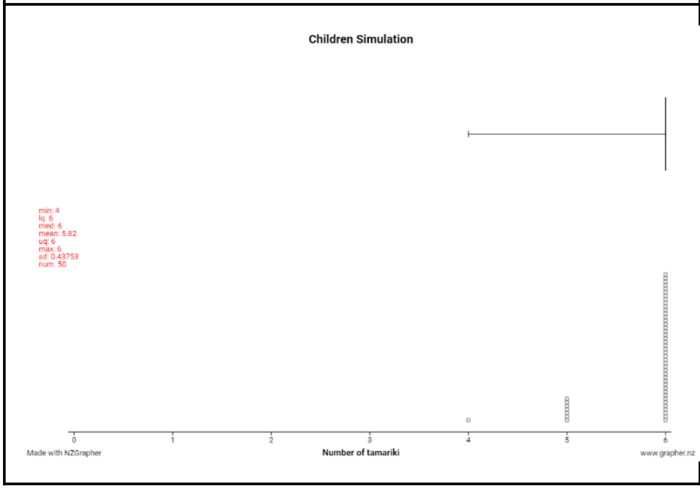
Step 6:

Also make a Dot plot and box plot of your data, adding the summary statistics, so that you can also have the mean and median values to analyse.

Results:







Exercise 11:

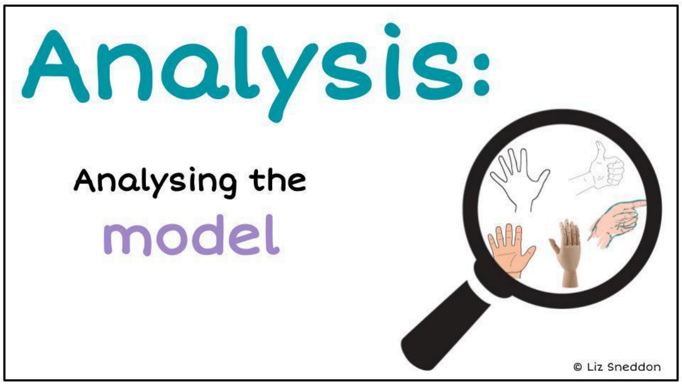
Generate simulation data in Excel for each of the following situations. Then generate graphs and summary statistics for your results.

1) There are three common PE games that teachers can use if the weather is wet. On a wet day there is a 10% chance that a teacher will choose to play table tennis, a 50% chance to play basketball, or a 40% chance to play volleyball. We want to investigate the chance of a class playing all three games over 5 wet days.

2) Mrs Sneddon has a kete (basket) with highlighters for students to use, including 14 kōhai (yellow), 18 kākāriki (green), 6 kikorangi (blue) and 2 māwhero (pink). Mrs Sneddon wants to investigate getting all four colours of highlighters out when she selects up to 10 highlighters at random.

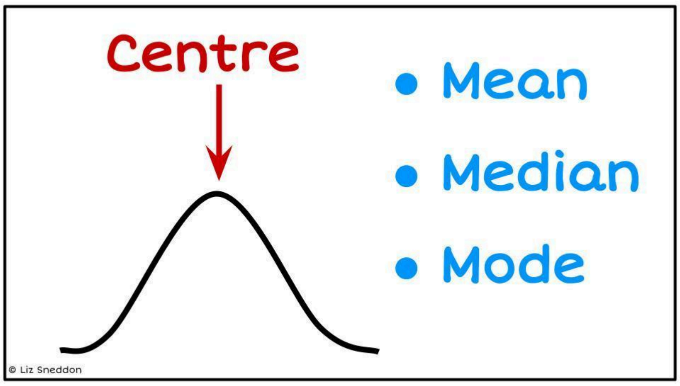
3) Screwdrivers often come in a set of 5, all different sizes and head shapes. When building a set of shelves there is a 38% chance of needing to use the large slot head, a 22% of needing to use the large Phillips head, a 14% chance of needing to use the square head, a 15% chance of needing to use the small slot head, and an 11% chance of needing to use the small Phillips head screwdriver. You need to investigate the chance of needing to use all five of the different screwdrivers when building the shelves , which have 12 screws.

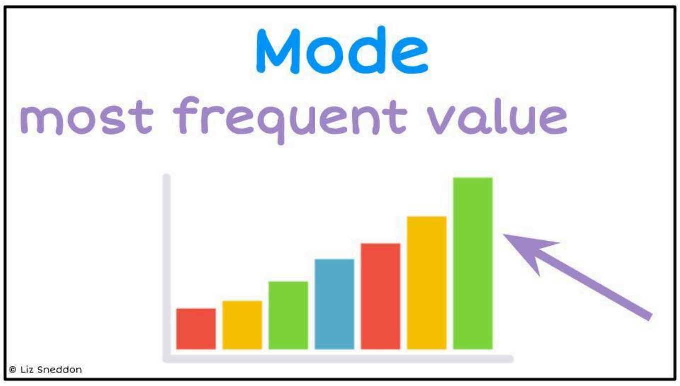
Analysis / Kaupapa

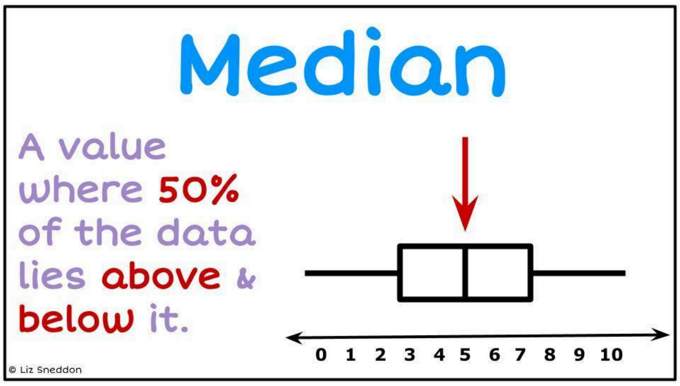


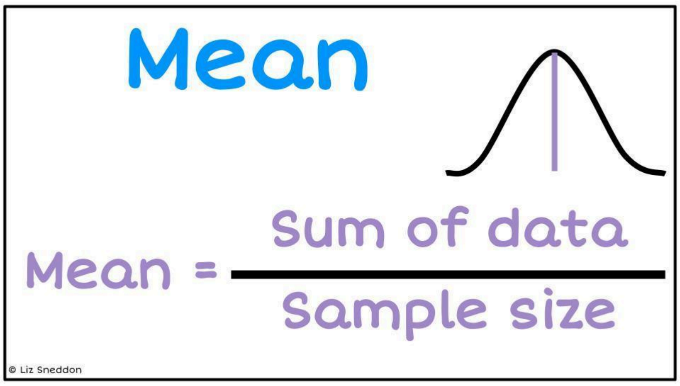
Once we have the data displayed in both tables and graphs, it is then time to look for patterns and discuss the features in the data. The features to look for include:

- Centre: mode, median, and/or mean
- Whole distribution: Frequencies or probabilities
- Any other patterns (including shape for numeric data).



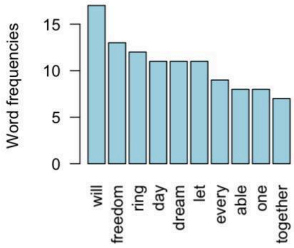






Frequency

the number of times an event occurs



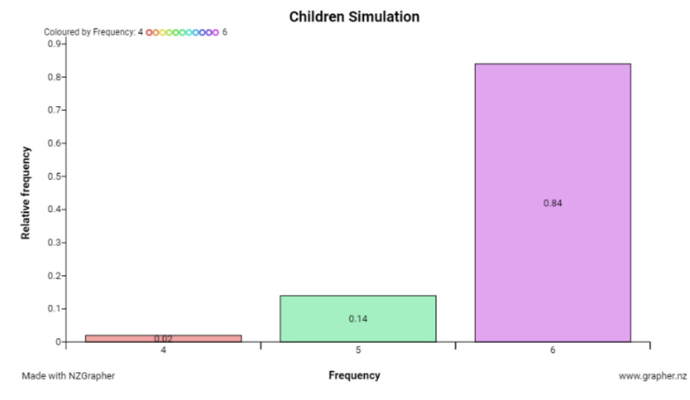
Relative Frequency

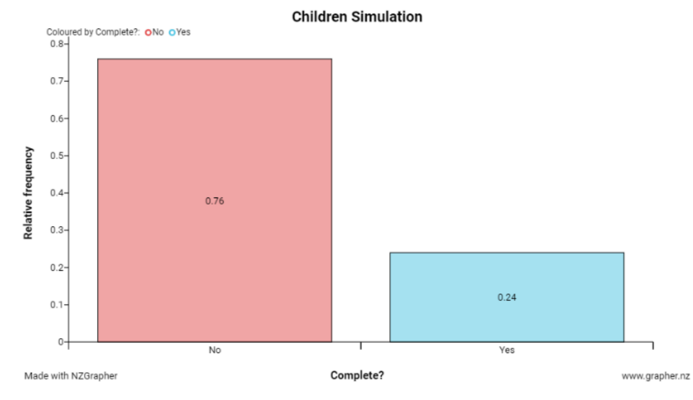
$$P(\text{event}) = \frac{\text{Frequency of outcome}}{\text{Total number of outcomes}}$$

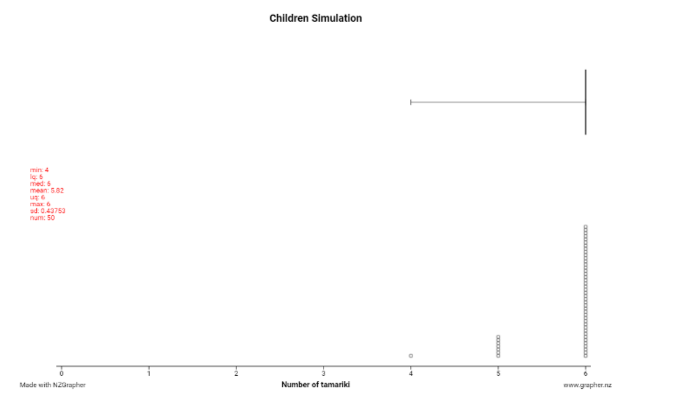
Example:

Situation:	The probability of a tamariki/child being born with blue eyes is 0.3, being born with brown eyes is 0.4, being born with green eyes is 0.2, and being born with grey eyes is 0.1. A married couple are planning to have a maximum of 6 children but would stop having children if they got all four eye colours.

Results:







Centre	The **most common** number of children for the couple to have is **six**, with a probability of 84%. The **mean** number of children for the couple to have is **5.82**. The **median** number of children for the couple to have is **6**.

	With a maximum of six children, it is **most likely** that the couple do **NOT** have children with all four different coloured eyes (probability is 76%).
The whole distribution	The chance of the couple having 4 children is 2%, while the chance of the couple having 5 children is 14%. The chance that the couple have up to six children AND have all four eye colours is 24%.
Shape	The shape of the distribution of the number of children the couple have is roughly left skewed

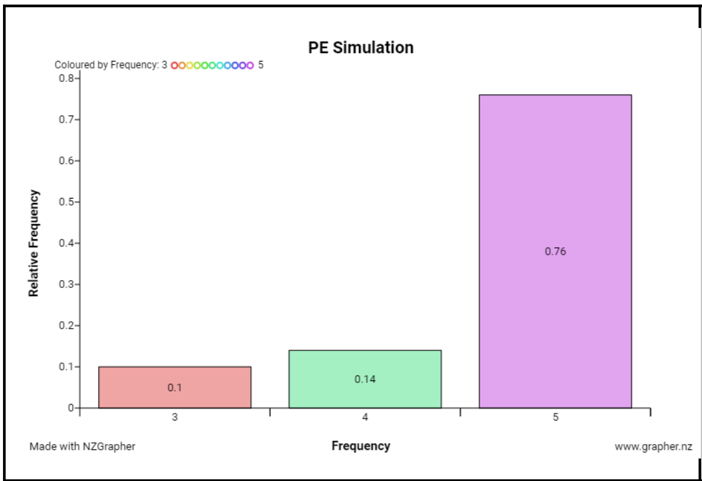
Exercise 12:

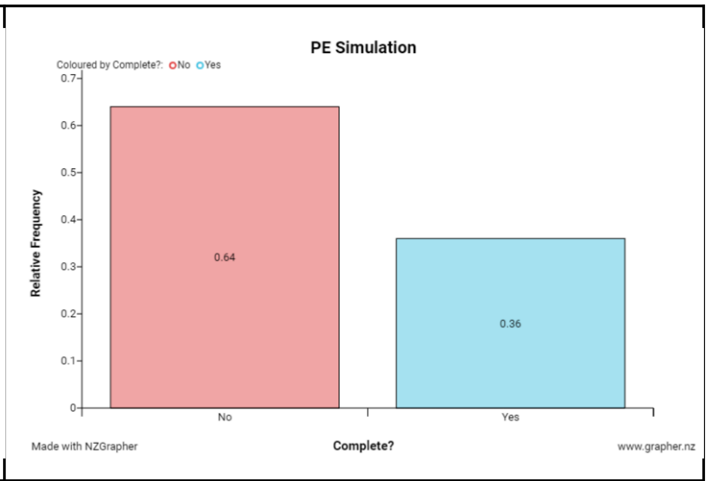
For each spreadsheet that you have made, for the three scenarios in Exercise 8, look at the graphs and summary statistics and write up an analysis of this.

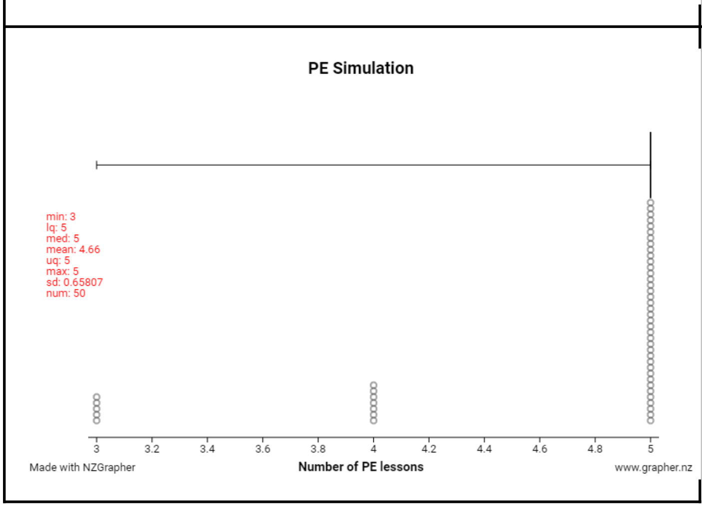
1)

Scenario	There are three common PE games that teachers can use if the weather is wet. On a wet day there is a 10% chance that a teacher will choose to play table tennis, a 50% chance to play basketball, or a 40% chance to play volleyball. We want to investigate the chance of a class playing all three games over 5 wet days.

Results





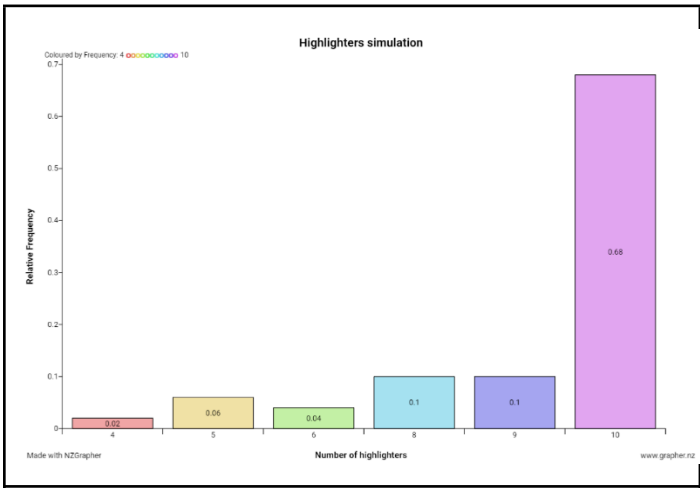


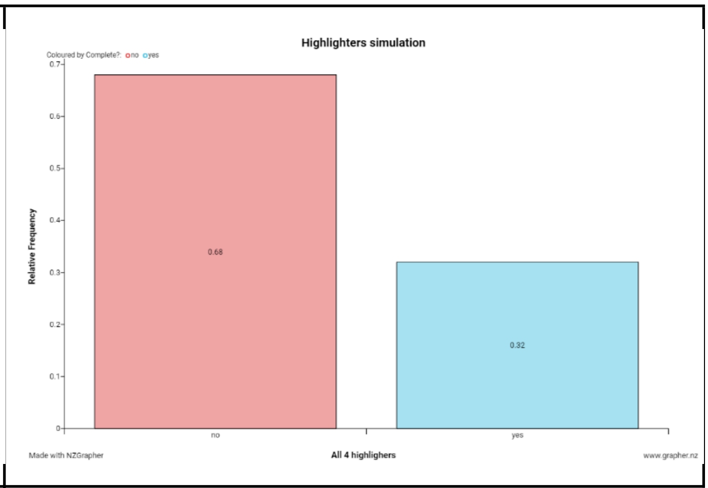
Centre	
The whole distribution: Frequencies or relative frequencies	
Other patterns	

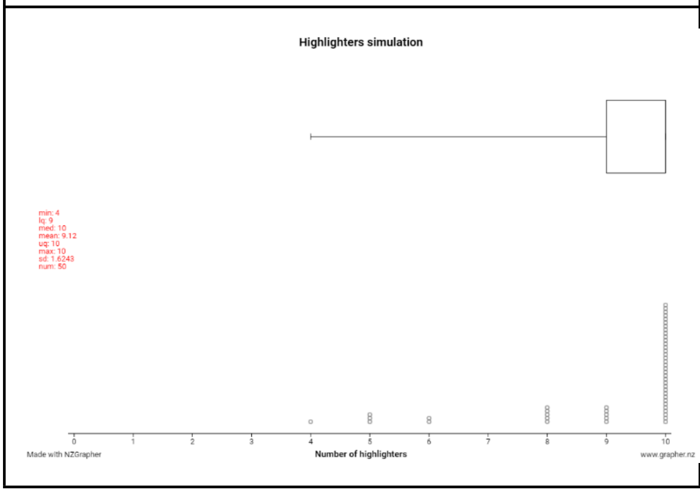
2)

Scenario	Mrs Sneddon has a kete (basket) with highlighters for students to use, including 14 kōhai (yellow), 18 kākāriki (green), 6 kikorangi (blue) and 2 māwhero (pink). Mrs Sneddon wants to investigate getting all four colours of highlighters out when she selects up to 10 highlighters at random.	

Results





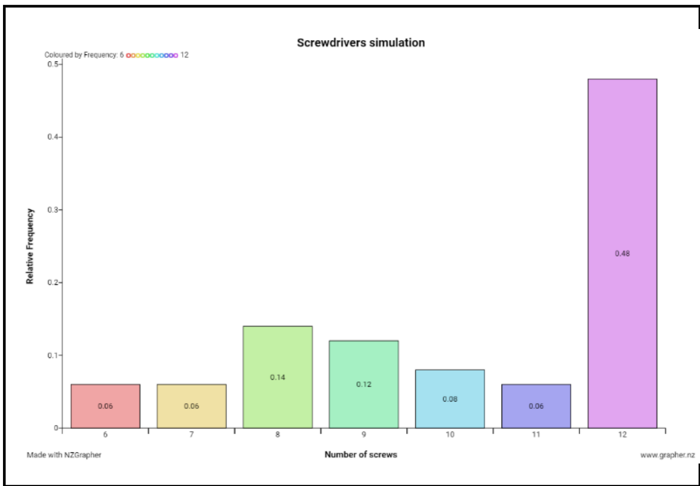


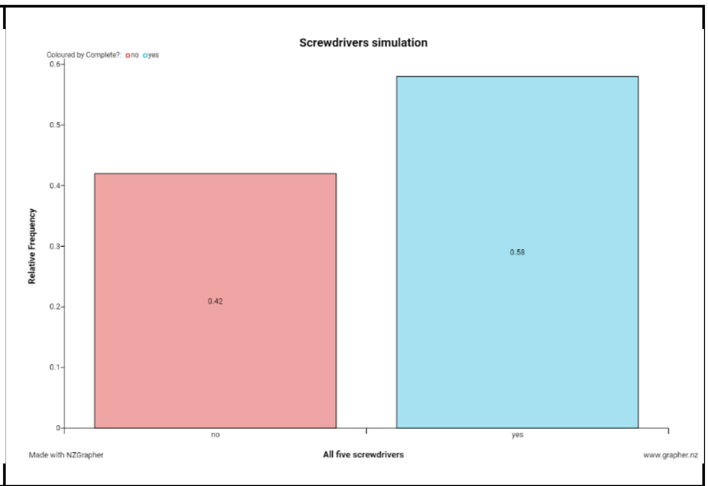
Centre	
The whole distribution: Frequencies or relative frequencies	
Other patterns	

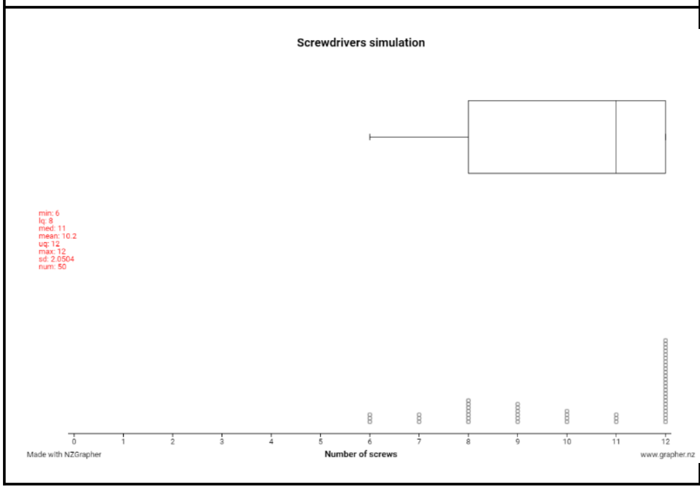
3)

Scenario	Screwdrivers often come in a set of 5, all different sizes and head shapes. When building a set of shelves there is a 38% chance of needing to use the large slot head, a 22% of needing to use the large Phillips head, a 14% chance of needing to use the square head, a 15% chance of needing to use the small slot head, and an 11% chance of needing to use the small Phillips head screwdriver. You need to investigate the chance of needing to use all five of the different screwdrivers when building the shelves, which have 12 screws. 

Results

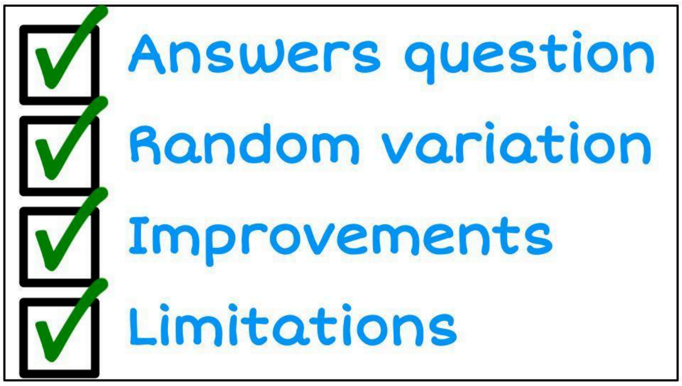






Centre	
The whole distribution: Frequencies or relative frequencies	
Other patterns	

Conclusion / Whakatau



You need to connect your model back to the real-world problem that you are modelling/simulating.

Answer the investigation question

Remember that there are two types of investigation questions that you could ask.

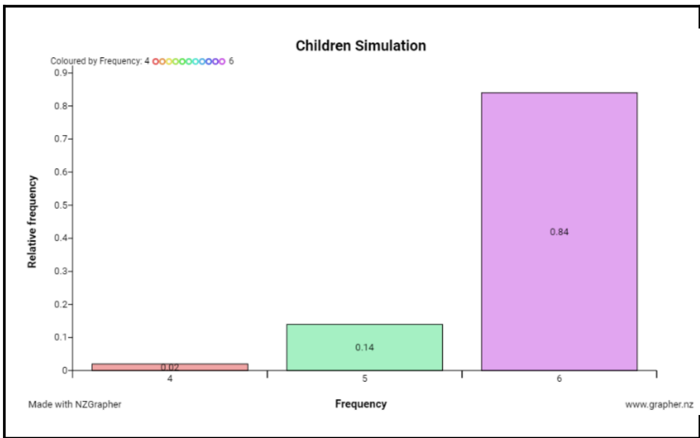
- Investigate the **probability** that an event occurs
- Investigate the **mean (average) / median number of times** that an event occurs.

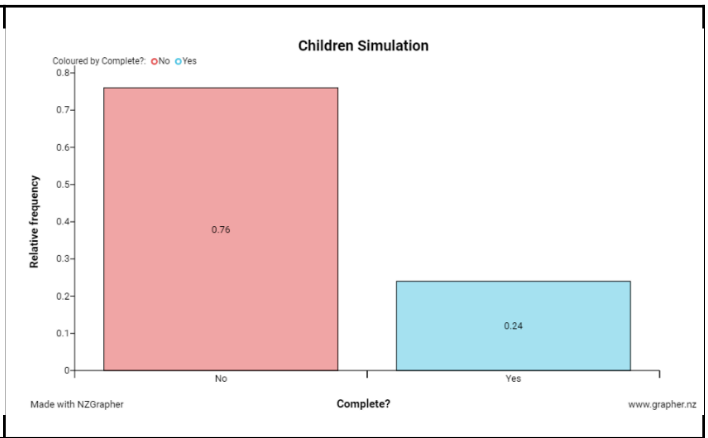
We need to answer the investigation question in context, remembering that the simulation model that we built is an estimate of the true probability or mean.

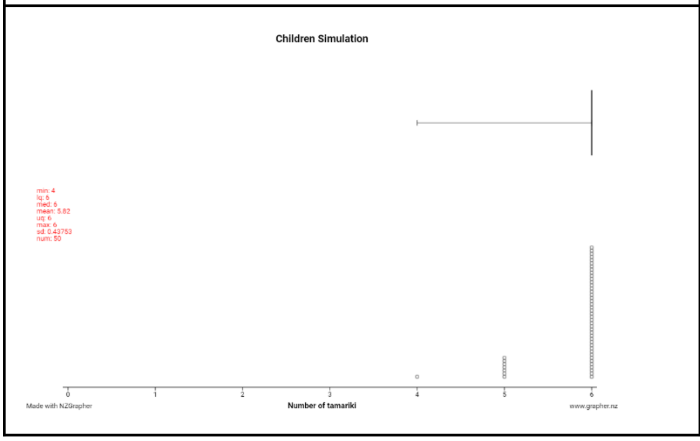
Example:

Situation:	The probability of a tamariki/child being born with blue eyes is 0.3, being born with brown eyes is 0.4, being born with green eyes is 0.2, and being born with grey eyes is 0.1. A married couple are planning to have a maximum of 6 children but would stop having children if they got all four eye colours.

Results:







Probability question	The probability of the family having children with all four eye colours, given the maximum number of children the couple want to have, is 24%.
Mean question	The mean number of children the couple would have, with the limit of six children and stopping if they got all 4 eye colours, is 5.82.

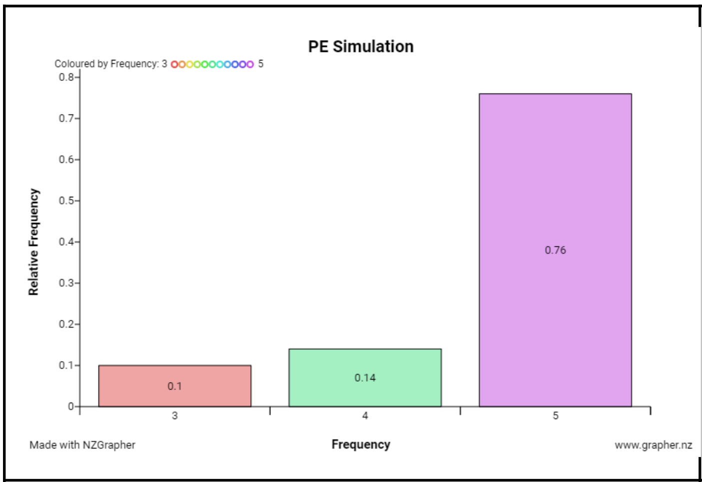
Exercise 13:

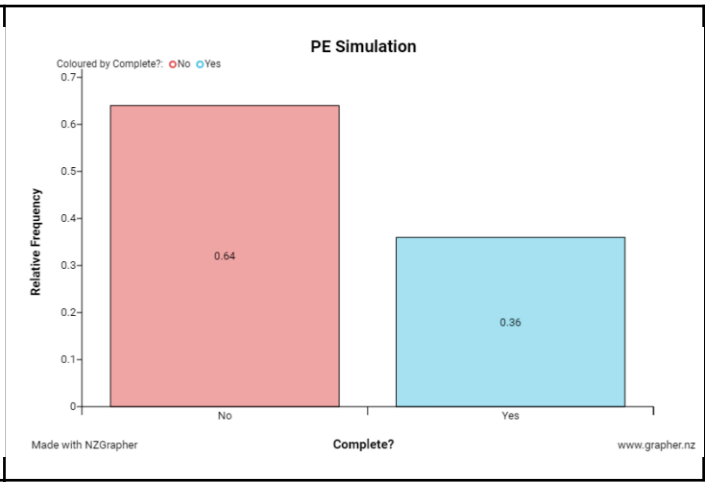
For each spreadsheet that you have made, for the three scenarios in Exercise 8, look at the graphs and summary statistics and write up an analysis of this.

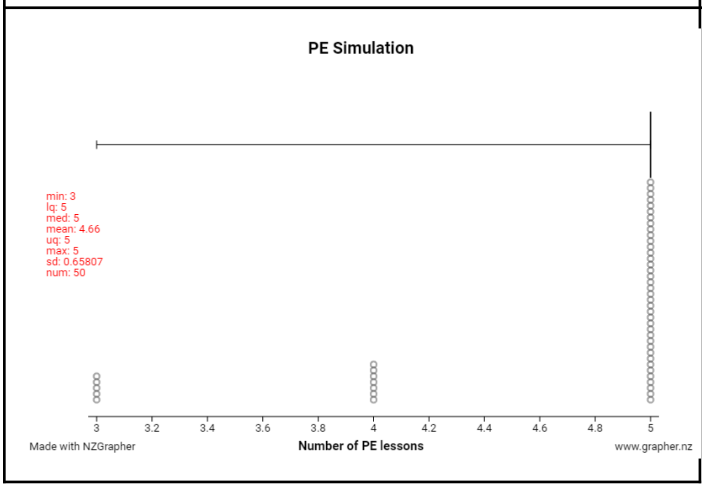
1)

Scenario	There are three common PE games that teachers can use if the weather is wet. On a wet day there is a 10% chance that a teacher will choose to play table tennis, a 50% chance to play basketball, or a 40% chance to play volleyball. We want to investigate the chance of a class playing all three games over 5 wet days.

Results







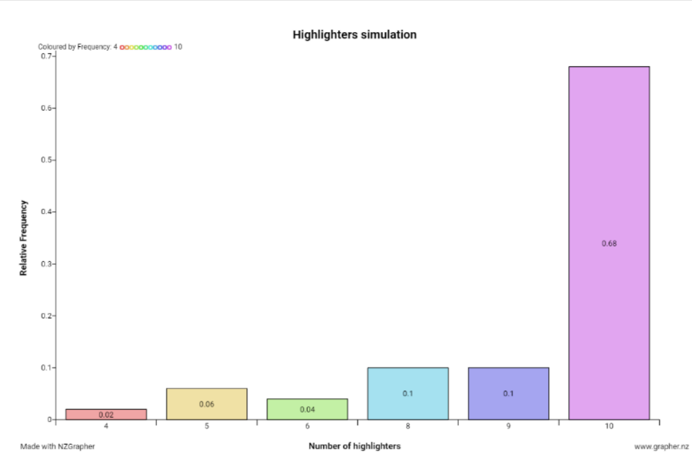
Probability question	

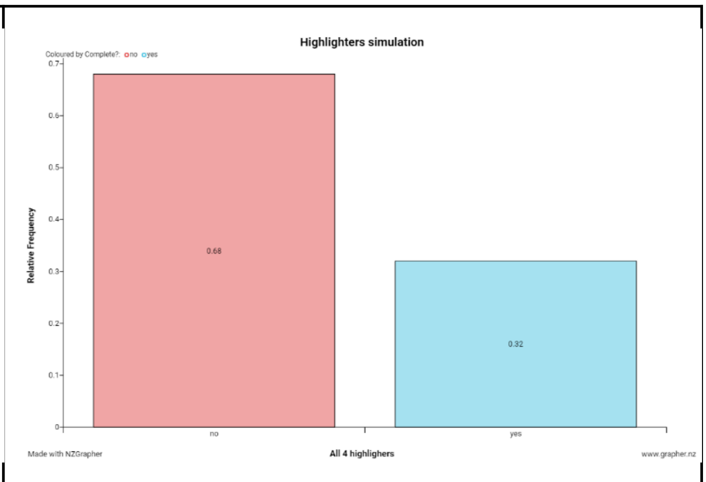
Mean question	

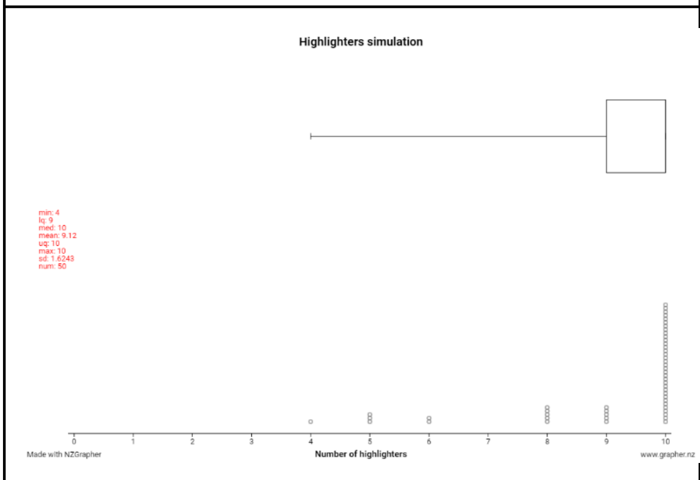
2)

Scenario	Mrs Sneddon has a kete (basket) with highlighters for students to use, including 14 kōhai (yellow), 18 kākāriki (green), 6 kikorangi (blue) and 2 māwhero (pink). Mrs Sneddon wants to investigate getting all four colours of highlighters out when she selects up to 10 highlighters at random.	

Results





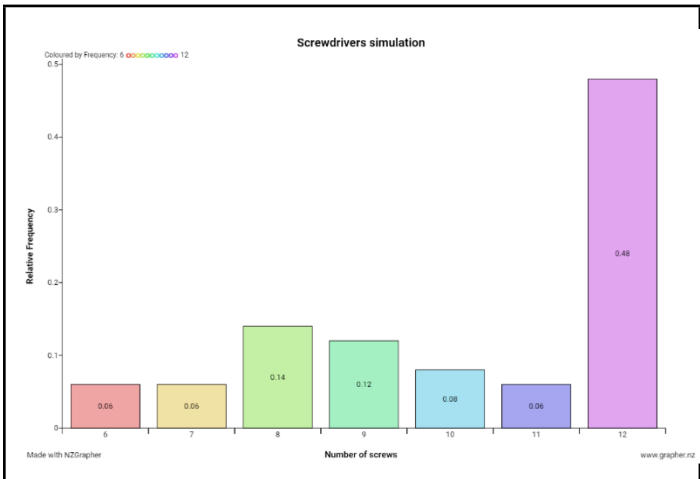


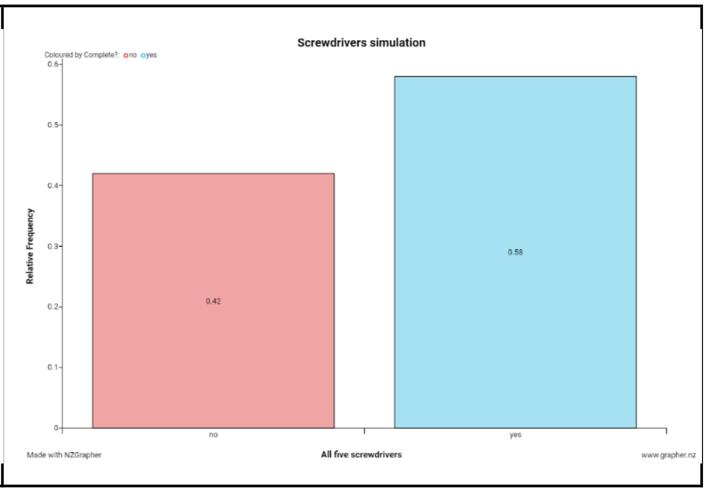
Probability question	
Mean question	

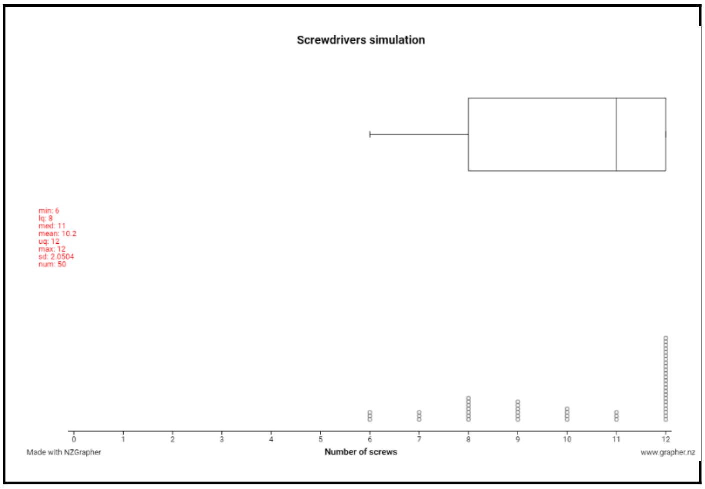
3)

Scenario	Screwdrivers often come in a set of 5, all different sizes and head shapes. When building a set of shelves there is a 38% chance of needing to use the large slot head, a 22% of needing to use the large Phillips head, a 14% chance of needing to use the square head, a 15% chance of needing to use the small slot head, and an 11% chance of needing to use the small Phillips head screwdriver. You need to investigate the chance of needing to use all five of the different screwdrivers when building the shelves, which have 12 screws.	

Results







Probability question	
Mean question	

Random variation

Each time we run another simulation, we will generate different random numbers, which will lead to different estimates of the probability and the mean. However, we want to understand that while these estimates vary, they aren't likely to vary a lot, unless we have a small number of trials.

However, we do need to think about the limitations and assumptions of our model, and how this means that our simulation is not modelling the real-world problem as well as we would like.

Example:

Situation:	The probability of a tamariki/child being born with blue eyes is 0.3, being born with brown eyes is 0.4, being born with green eyes is 0.2, and being born with grey eyes is 0.1. A married couple are planning to have a maximum of 6 children but would stop having children if they got all four eye colours.

Random variation:

Probability	If I ran another simulation, I would generate different random numbers. However, I would expect the estimates of the probability of having a maximum of six children who have 4 different coloured eyes to be similar to the estimate I obtained of 76%.
Mean	If I ran another simulation, I would generate different random numbers. However, the mean number of children the couple would have, with the limit of six children and stopping if they got all 4 eye colours, is likely to be similar to my estimate of 5.82 children.