Quantitative Research

WHAT USE QUANTITATIVE RESEARCH AND WHY MIGHT I USE IT?

Quantitative research is the process of collecting and analyzing numerical data. It can be used to find patterns and averages, make predictions, test relationships, test hypothesis and potentially generalise results.

Quantitative research question examples

How has school exclusion rates changed in Wales over the last 10 years?

Does regular retrieval practice impact learners test scores?

Does pupil engagement increase productivity for lower ability learners?

WHY USE QUANTITATIVE RESEARCH METHODS?

Quantitative research methods (taken from What Is Quantitative Research? | Definition, Uses & Methods (scribbr.com)

You can use quantitative research methods for descriptive, correlational or experimental research.

- In descriptive research, you simply seek an overall summary of your study variables.
- In correlational research, you investigate relationships between your study variables.
- In experimental research, you systematically examine whether there is a cause-and-effect relationship between variables.

Correlational and experimental research can both be used to formally test hypotheses, or predictions, using statistics. The results may be generalized to broader populations based on the sampling method used.

To collect quantitative data, you will often need to operationalise your variables, i.e. have definitions that translate abstract concepts (e.g. engagement, enjoyment, participation) into observable and quantifiable measures

Quantitative Data Handling

Types of data

Quantitative

Qualitative

Discrete

Continuous

Levels/Scales of Measurement

Recognising the levels of measurement will help you to decide *how* to interpret the data.

Knowing the level of measurement helps you, as a researcher, decide what statistical analysis is appropriate on the values that you have collected and what graph representation should be used to present the data/results.

Levels/Scales of Measurement

Ratio

Interval

Ordinal

Nominal

* LET'S TAKE A CLOSER LOOK AT EACH OF THE FOUR LEVELS

	Properties/ Characteristics	Examples	Descriptive Statistics	Graphs/chart
Nominal data				
Ordinal data				
Interval data				
Ratio data				

Visit Levels of Measurement | Nominal, Ordinal, Interval and Ratio (scribbr.com) to help you complete the table

NOMINAL LEVEL DATA

Properties/Characteristics

Nominal data does not have a numerical value. Can be categorised into mutually exclusive groups. The response option/groups cannot be put into a hierarchy or order.

Examples

Hair colour, ethnicity, sex

What statistics can we find?

Mode

What charts/graphs can we use?

Bar chart, pie chart

ORDINAL LEVEL DATA

Properties/Characteristics

Ordinal data does not have a numeric value. The data can be categorised and the use of numerical codes can be assigned to textual responses. The response options can be put into a hierarchy or order, but the intervals between them cannot be commented upon – they cannot be presumed to be equal

Examples

Ratings of feelings/satisfaction towards something.

Competency of swimming ability

What statistics can we find?

Mode response. Comment on frequencies. Calculate proportions (percentages/fractions).

What charts/graphs can we use?

Pie charts, bar chart

INTERVAL LEVEL DATA

Properties/Characteristics

Differences between the values are equal and have meaning. Values exist below zero, therefore zero is not the lowest value.

Examples

Standardised test. Temperature scale in C or F.

What statistics can we find?

Mean, Mode, Median. Standard deviation. Percentiles and Interquartile range.

What charts/graphs can we use?

Bar chart, Frequency diagram (grouped data), Histogram, Box Plot, linegraph

RATIO LEVEL DATA

Properties/Characteristics

Differences between the values are equal and have meaning. Continuous data. True zero starting point – ratios can be calculated

Examples

Age, weight, height, …

What statistics can we find?

Mean, Mode, Median. Standard deviation. Percentiles and Interquartile range.

What charts/graphs can we use?

Bar chart, Frequency diagram (grouped data), Histogram, Box Plot, linegraph

QUESTIONNAIRES

Questionnaires can be classified as
both quantitative and qualitative methods depending on the nature of questions.

DICHOTOMOUS QUESTIONS

These type of questions gives two options to respondents –

Yes or No,

True or False

This is **Nominal data**

Properties/Characteristics

Discrete data. Qualitative. Order is not important

What statistics can we find?

Mode response. Comment on frequencies. Calculate proportions (percentages/fractions)

What charts/graphs can we use?

Frequencies – Bar chart

Proportions – Pie chart

SCALING QUESTIONS

Also referred to as ranking questions, they present an option for respondents to rank the available answers to the questions on the scale of given range of values (for example from 1 to 5).

This is **Ordinal data. Example: Likert Scale**

Properties/Characteristics

Ranked. Satisfaction scales. Qualitative. Ordered categories. Meaningful order, but the intervals may not be equal – the space between ranks is subjective

What statistics can we find?

Mode response. Comment on frequencies. Calculate proportions (percentages/fractions).

What charts/graphs can we use?

Frequencies – Bar chart

Examples of Likert Scales

Agreement

Strongly agree
Agree
Undecided
Disagree
Strongly disagree

Frequency

Very frequently
Frequently
Occasionally
Rarely
Never

Importance

Very important
Important
Moderately important
Of little importance
Unimportant

Likelihood

Almost always true
Usually true
Occasionally true
Usually not true
Almost never true

MEASURES OF CENTRAL TENDENCY

VISIT CENTRAL TENDENCY | UNDERSTANDING THE MEAN, MEDIAN & MODE (SCRIBBR.COM)

Types of calculations.
Measures of central tendency help you find the central or 'average' value. The most common measures of central tendency are the arithmetic mean, the median, and the mode.

TWO GROUPS OF 5 CHILDREN ARE TIMED COMPLETING AN ACTIVITY

Group 1 Times (mins)	Group 2 Times (mins)
15	2
15	7
14	14
15	22
16	30

What does the data tell us?

We need to do some number crunching

MEAN AND STANDARD DEVIATION

USING EXCEL

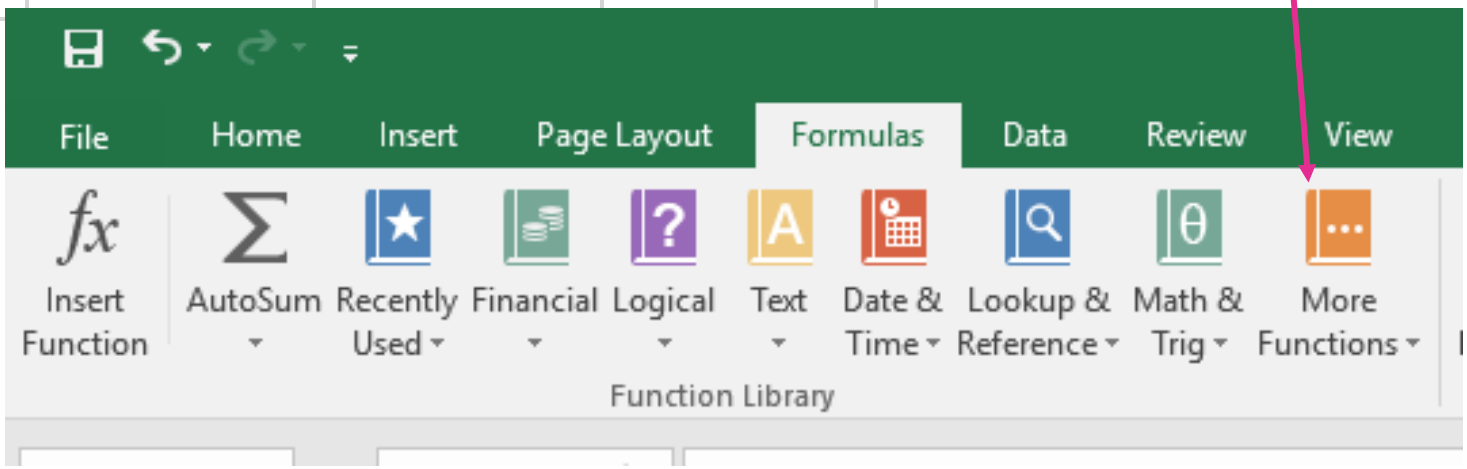
Descriptive Statistics.

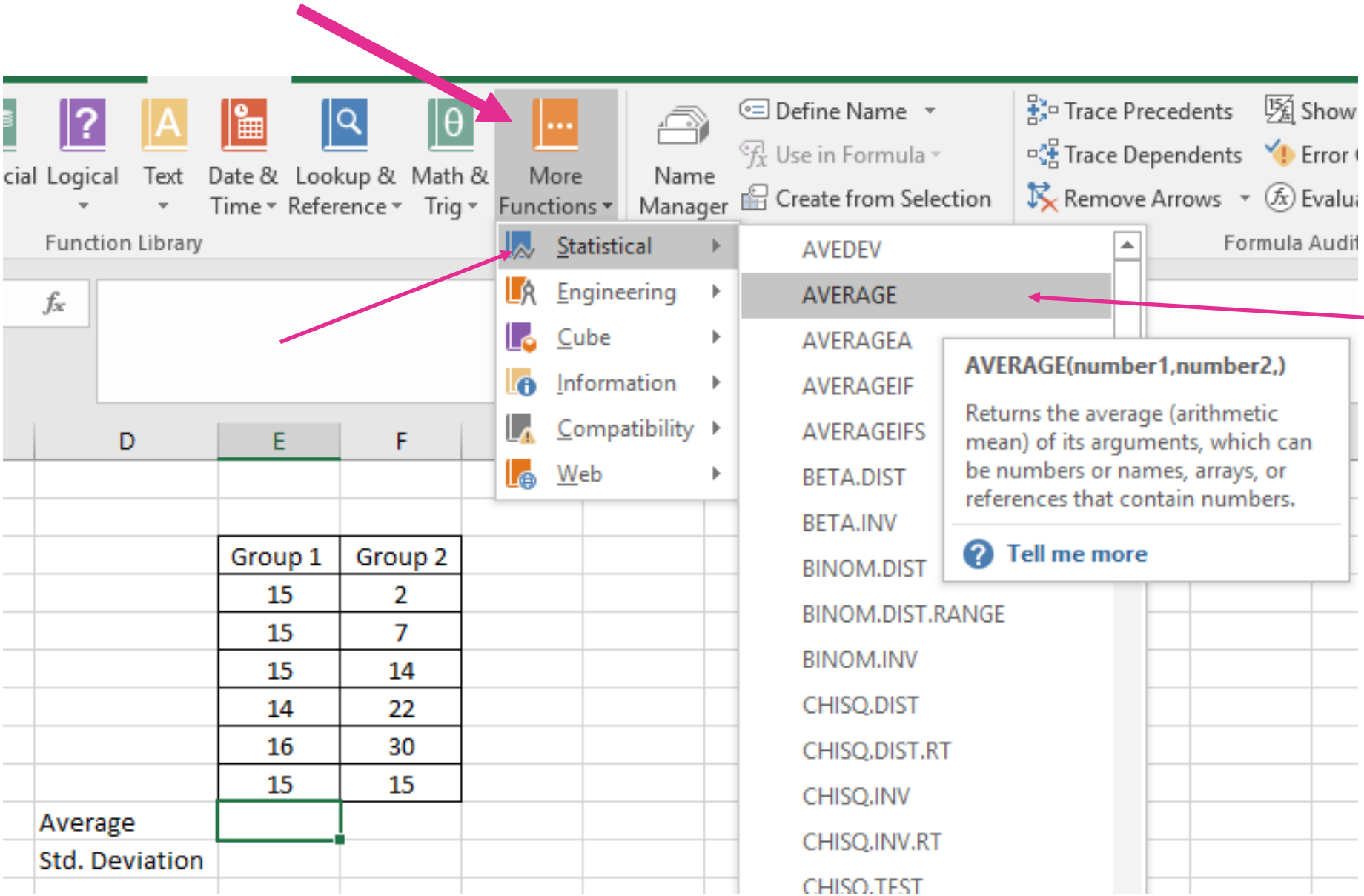
mean and standard deviation examples

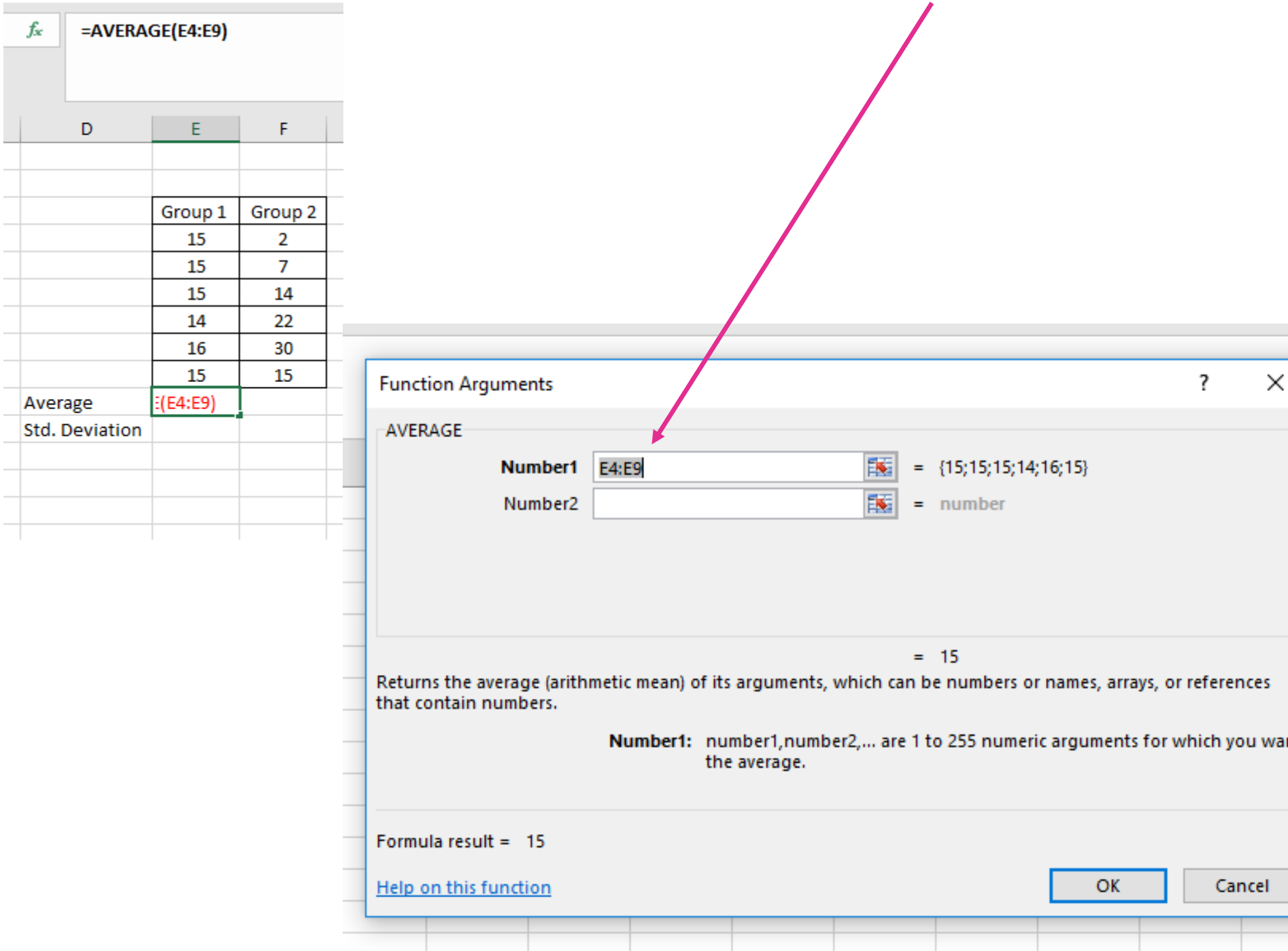
Group 1	Group 2
15	2
15	7
15	14
14	22
16	30
15	15

Average

Std Dev.




Logical
Text
Date & Time
Lookup & Reference
Math & Trig
More Functions
Name Manager
Define Name
Use in Formula
Create from Selection
Trace Precedents
Trace Dependents
Remove Arrows
Function Library
Formula Audit
Statistical
Engineering
Cube
Information
Compatibility
Web
AVEDEV
AVERAGE
AVERAGEA
AVERAGEIF
AVERAGEIFS
BETA.DIST
BETA.INV
BINOM.DIST
BINOM.DIST.RANGE
BINOM.INV
CHISQ.DIST
CHISQ.DIST.RT
CHISQ.INV
CHISQ.INV.RT
CHISQ.TEST
AVERAGE(number1,number2,)
Returns the average (arithmetic mean) of its arguments, which can be numbers or names, arrays, or references that contain numbers.
Tell me more
D
E
F
Group 1
Group 2
15
2
15
7
15
14
14
22
16
30
15
15
Average
Std. Deviation


=AVERAGE(E4:E9)
D
E
F
Group 1
Group 2
15
2
15
7
15
14
14
22
16
30
15
15
Average
(E4:E9)
Std. Deviation
Function Arguments
AVERAGE
Number1
E4:E9
= {15;15;15;14;16;15}
Number2
= number
= 15
Returns the average (arithmetic mean) of its arguments, which can be numbers or names, arrays, or references that contain numbers.
Number1: number1,number2,... are 1 to 255 numeric arguments for which you wa
the average.
Formula result = 15
Help on this function
OK
Cancel

fx =AVERAGE(F4:F9)

	D	E	F
		Group 1	Group 2
		15	2
		15	7
		15	14
		14	22
		16	30
		15	15
	Average	15	:(F4:F9)
	Std. Deviation		

Function Arguments

AVERAGE

Number1 F4:F9 = {2;7;14;22;30;15}

Number2 = number

= 15

Returns the average (arithmetic mean) of its arguments, which can be numbers or names, that contain numbers.

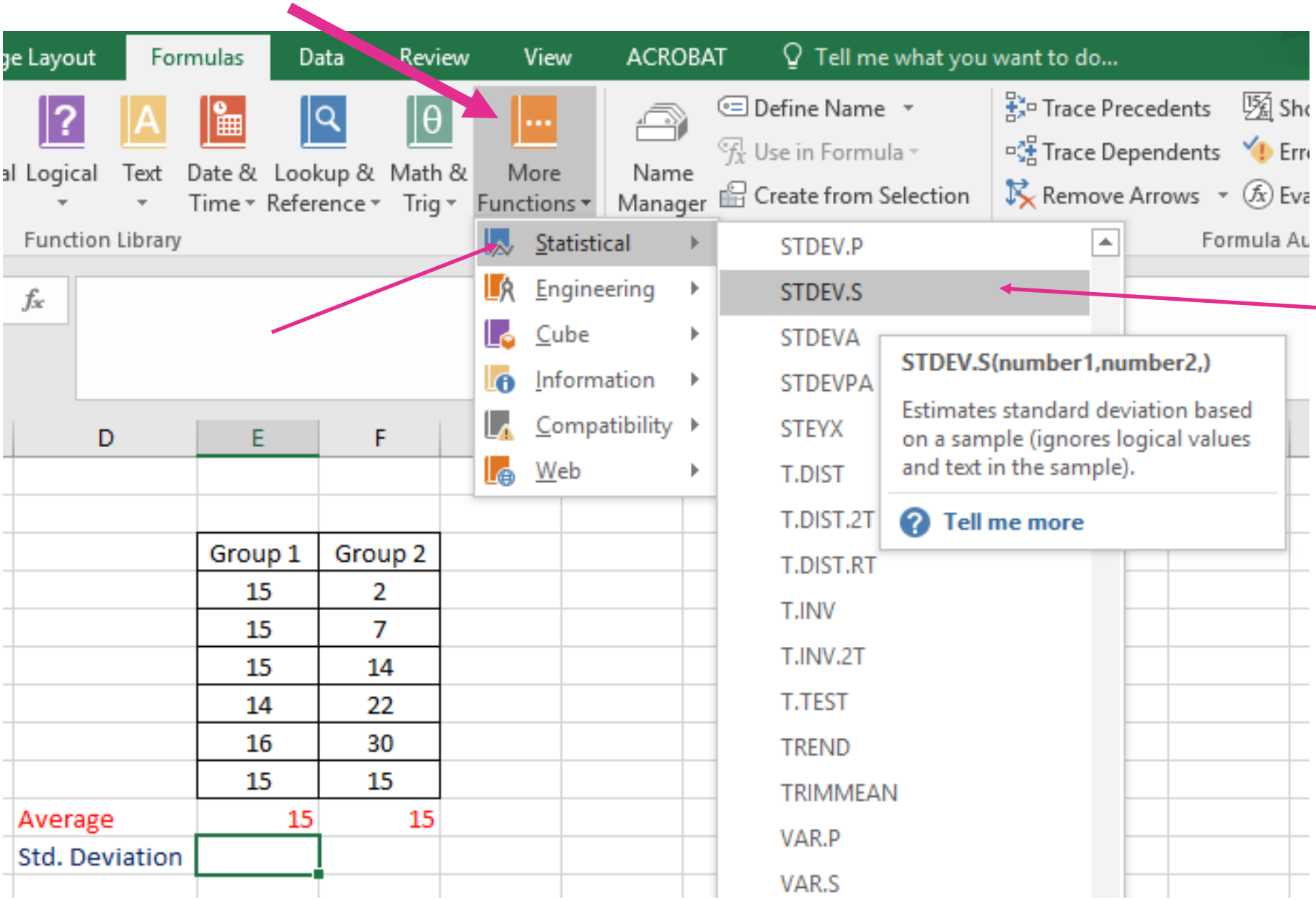
Number1: number1,number2,... are 1 to 255 numeric argum the average.

Formula result = 15

Help on this function

	Group 1	Group 2
	15	2
	15	7
	15	14
	14	22
	16	30
	15	15
Average	15	15
Std. Deviation		

Both groups of children, on average, took 15 minutes to complete the set task


Formulas
Data
Review
View
ACROBAT
Tell me what you want to do...
Logical
Text
Date & Time
Lookup & Reference
Math & Trig
More Functions
Name Manager
Define Name
Use in Formula
Create from Selection
Trace Precedents
Trace Dependents
Remove Arrows
Function Library
Statistical
Engineering
Cube
Information
Compatibility
Web
STDEV.P
STDEV.S
STDEVA
STDEVPA
STEYX
T.DIST
T.DIST.2T
T.DIST.RT
T.INV
T.INV.2T
T.TEST
TREND
TRIMMEAN
VAR.P
VAR.S
STDEV.S(number1,number2,)
Estimates standard deviation based on a sample (ignores logical values and text in the sample).
Tell me more
D
E
F
Group 1
Group 2
15
2
15
7
15
14
14
22
16
30
15
15
Average
15
15
Std. Deviation

	Group 1	Group 2
	15	2
	15	7
	15	14
	14	22
	16	30
	15	15
Average	**15**	**15**
Std. Deviation	0.632456	10.07968
Std. Deviation	**0.6**	**10.1**

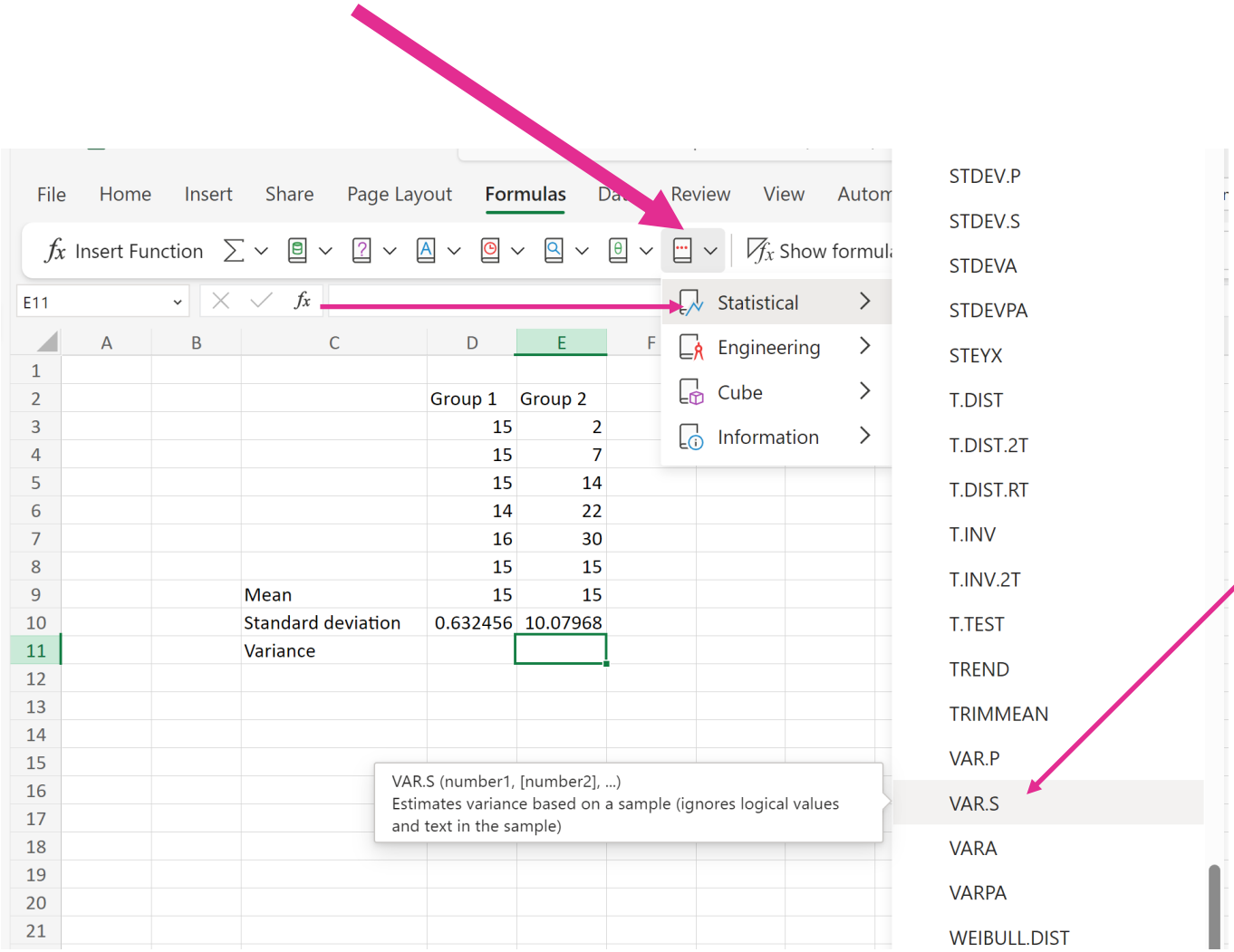
Standard deviation shows the variation in data – how spread out the data is around the mean value

MEASURE OF DISPERSION

In statistics, the **standard deviation** is a measure of spread or dispersion. It tells us how far, on average, the results are from the mean. A low standard deviation indicates that the values tend to be close to the mean of the set, while a high standard deviation indicates that the values are spread out over a wider range.

We can also consider the **variance,** which is the spread between numbers in a data set. Variance is a statistical measurement used to determine how far each number is from the mean and from every other number in the set.

The more spread the data, the larger the variance is in relation to the mean


File
Home
Insert
Share
Page Layout
Formulas
Review
View
Insert Function
Show formula
E11
Statistical
Engineering
Cube
Information
Group 1
Group 2
15 2
15 7
15 14
14 22
16 30
15 15
Mean 15 15
Standard deviation 0.632456 10.07968
Variance
VAR.S (number1, [number2], ...)
Estimates variance based on a sample (ignores logical values and text in the sample)
STDEV.P
STDEV.S
STDEVA
STDEVPA
STEYX
T.DIST
T.DIST.2T
T.DIST.RT
T.INV
T.INV.2T
T.TEST
TREND
TRIMMEAN
VAR.P
VAR.S
VARA
VARPA
WEIBULL.DIST

	Group 1	Group 2
	15	2
	15	7
	15	14
	14	22
	16	30
	15	15
Mean	15	15
Standard deviation	0.632456	10.07968
Variance	**0.4**	**101.6**

VARIABILITY

Variability helps us to understand more about the spread/scatter/dispersion of results a dataset. It describes how far apart data points lie from each other and from the centre of a distribution.

When variability is calculated **in addition** to measures of central tendency you are provided with descriptive statistics to help you summarise your data.

Variability is commonly measured with the following:
Range: calculated by subtracting the lowest value from the highest value
Interquartile range: is the range of the 'middle half' of the dataset/distribution
Standard deviation: average distance from the mean
Variance: average of squared distances from the mean

QUARTILES

Quartiles are the values that divide a list of ordered numbers into quarters:

The 1st quartile – 25% of the way through the data set
The 2nd quartile – 50% of the way through the data set
The 3rd quartile – 75% of the way through the data set

Quartiles are the values that divide a list of ordered number into quarters:

Lower Quartile– 25% of the way through the data set
Median– 50% of the way through the data set
Upper quartile– 75% of the way through the data set

QUARTILES - EXAMPLE

The test scores from 13 pupils is given below (marked out of 20)

9, 10, 12, 14, 14, 15, 17, 17, 17, 18, 19, 20, 20

Quartiles are the values that divide a list of ordered number into quarters:

Lower Quartile– 25% of the way through the data set 13 points
Median– 50% of the way through the data set 17 points
Upper quartile– 75% of the way through the data set 18.5 points

We can also find the Interquartile range. This is the Upper Quartile – Lower Quartile
In this case IQR = 18.5 – 13 = 4.5

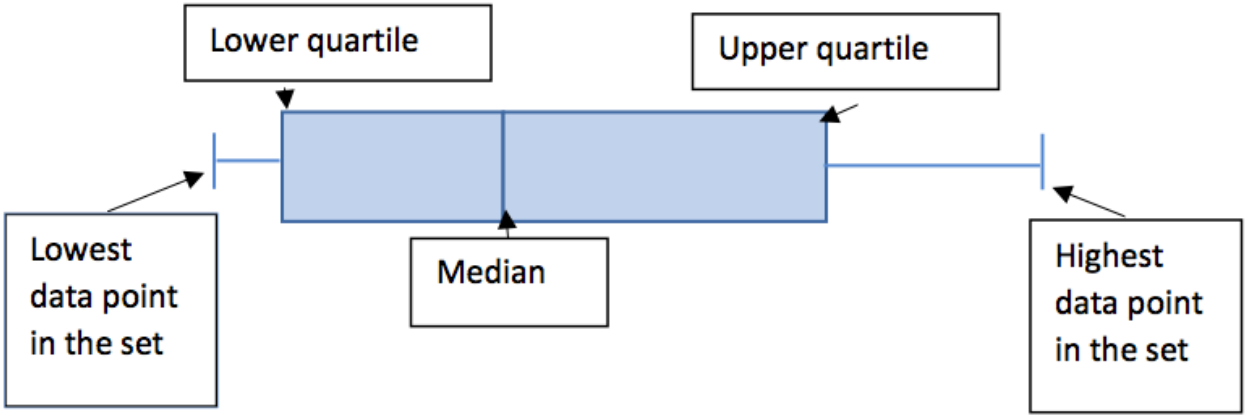
Visit Variability | Calculating Range, IQR, Variance, Standard Deviation (scribbr.com)

BOX PLOT

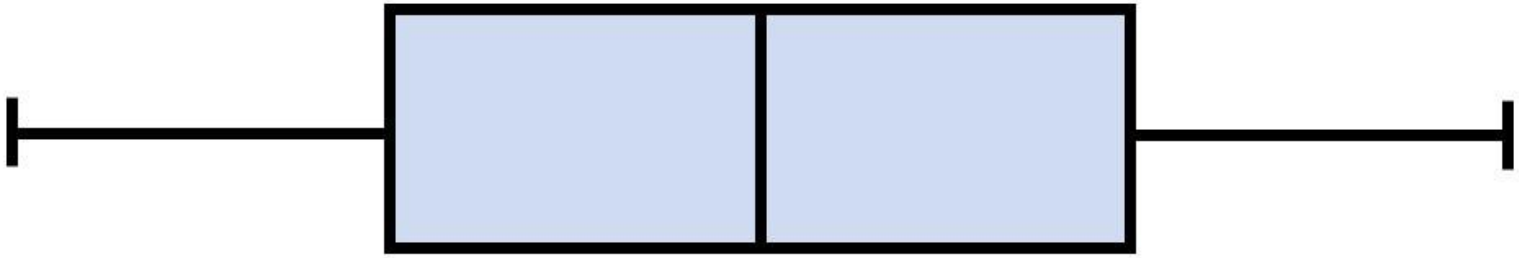
Quartiles are the values that divide a list of ordered number into quarters:

Lower Quartile– 25% of the way through the data set 13 points
Median– 50% of the way through the data set 17 points
Upper quartile– 75% of the way through the data set 18.5 points

This information can be represented using a Box Plot (also known as a Box and Whisker diagram)

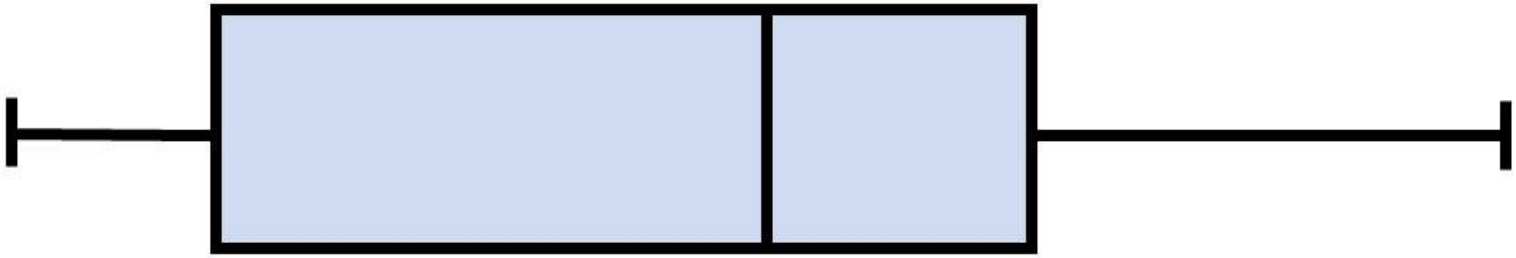


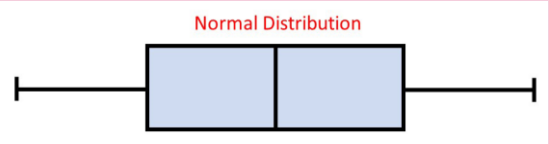
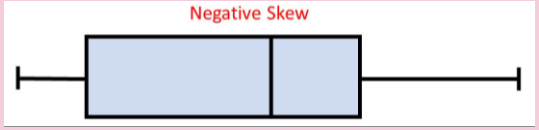
Normal Distribution



Positive Skew

Negative Skew



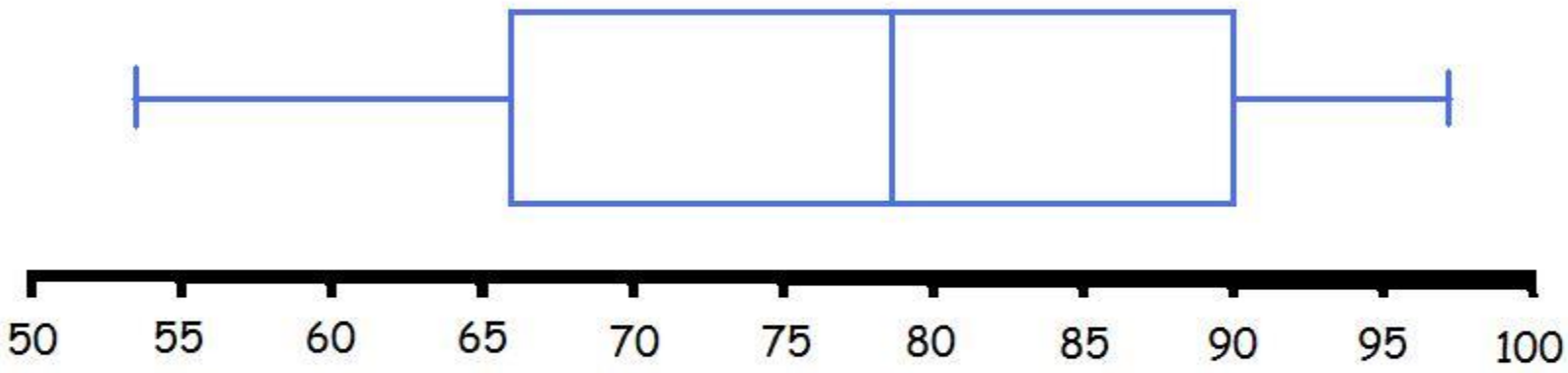
Skewness	What does the box plot look like	What does it mean
Normal Distribution 	Median in the centre	The data is evenly spread
Positive Skew	Median to the left of the box.	The data above the median is more widely spread
Negative Skew 	Median to the right of the box.	The data below the median is more widely spread

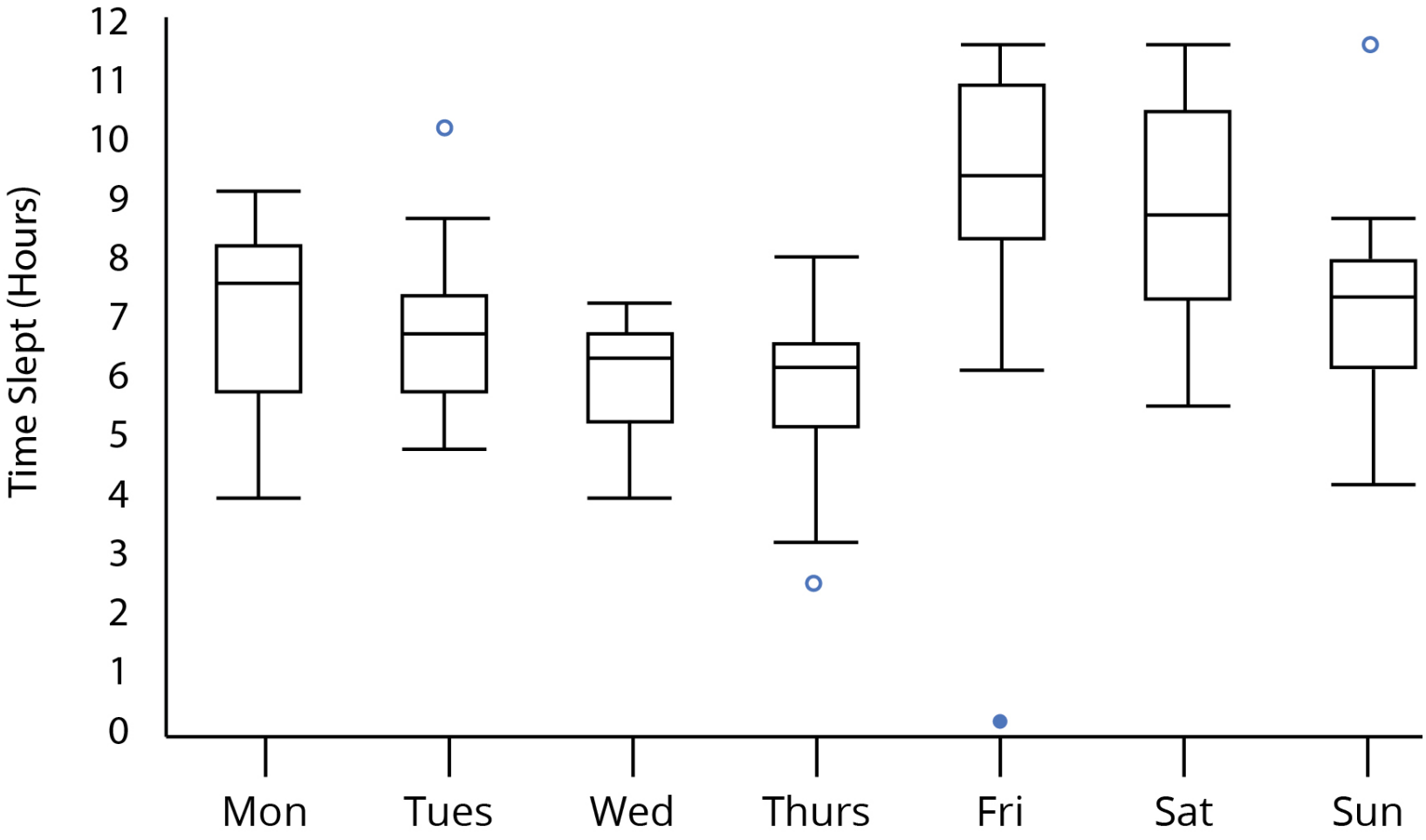
Remember each section of the box plot contains 25% of the data.

A smaller section indicates the data is more condensed (close together)

Variance (or variability) is described by the Interquartile Range (IQR). The larger the IQR, the more varied the data is. The IQR ignores outliers, therefore, if the data is skewed it is a more appropriate measure of variability than the standard deviation.

Scores on a math test




Time Slept (Hours)
12
11
10
9
8
7
6
5
4
3
2
1
0
Mon
Tues
Wed
Thurs
Fri
Sat
Sun

BOX PLOT AND OUTLIERS

Consider this data,

12, 23, 34, 37, 45, 49, 50, 60, 79, 120

Lower Quartile 34
Upper Quartile 60
IQR 60 – 34 = 22

To decide **if this data has any outliers**, use the following calculations to have the **range** you will accept.

Range we will accept
IQR - 1.5 TIMES THE FIRST AND IQR + 1.5 TIMES THE THIRD QUARTILE

IQR – 1.5 x Lower Quartile,	IQR + 1.5 x Upper Quartile
22 – 1.5x 34,	22 + 1.5 x 60
- 29,	112

120 does not fall in this range, therefore120 as an outlier

HYPOTHESES TESTING

VISIT HYPOTHESIS TESTING | A STEP-BY-STEP GUIDE WITH EASY EXAMPLES (SCRIBBR.COM)

STATISTICAL HYPOTHESIS TESTS

In order to test a hypothesis statistically we need two hypotheses –

a null hypothesis (called H_0)

And

an experimental or alternative hypothesis (called H_1)

STATISTICAL HYPOTHESIS TESTS

A null hypothesis (called H_0) – states there is NO STATISTICAL DIFFERENCE between sets of data or NO STATISTICAL RELATIONSHIP between data.
In other words, any observed difference is most likely by chance alone.

An experimental or alternative hypothesis (called H_1) – states there IS A STATISTICAL DIFFERENCE between sets of data or A STATISTICAL RELATIONSHIP between data.
In other words, it is unlikely that the difference occurred by chance alone.

When writing your hypothesis, you need to be specific depending on your context and what you are finding out

Testing hypotheses:

"I want to find out if there is a difference in mental arithmetic ability between boys and girls"

What would your H_0 and H_1 be?

In this case

H_0 is:
"There is no difference between boys' and girls' mental arithmetic ability"

H_1 is:
"There is a difference in mental arithmetic ability between boys and girls"
(2 tailed t- test)

STATISTICAL TESTS

There are a variety of statistical tests which are suited to different sample types.

Recall the 4 levels of measurement earlier, some statistical tests can only be used with specific types of data sets.

Good news – there is only some number crunching that you will have to do. The tests can be carried out in EXCEL, using a statistical package or downloadable specific statistical test calculator!

When you have carried out the statistical test, you will find a p value (probability value)

You will need to decide if this p value is significant…there are rules we follow

We need to compare the value we get to something

UNDERSTANDING THE P VALUE

The P Value stands for Probability Value and states how likely it is the results (from your research) occurred by chance alone.

If a p value is large it indicates that it is likely that these results have occurred by chance alone

If a p value is small it indicates that it is unlikely that these results have occurred by chance alone. Note: these results will then be known as being statistically significant.

How small is small, how large is large?

UNDERSTANDING THE P VALUE

In educational research the tradition is that

If the p value is greater than 0.05 researchers decide the results are not significant. *In other words any observed difference is most likely by chance alone*

P > 0.05 means probability value is greater than 5%

If the p value is less than 0.05 researchers decide the results are significant. *In other words any observed difference is unlikely to by chance alone*

P < 0.05 means probability value is less than 5%

ALPHA

The significance level, α, is **the probability of rejecting the null hypothesis when it is actually true**. For example, a significance level of 0.05 indicates a 5% risk of the researcher concluding that a difference exists when there is no actual difference. *In other words, the chance, written as a percentage that you have made a mistake and chosen the wrong hypothesis to accept.*

The researcher needs to decide the level of alpha being used for the testing.

The two most common ones are α = 0.05 and α = 0.01

When interpreting if a p value is significant (or not) the researcher refers to the α value they have chosen in order to make a direct comparison

α

In our earlier case of two hypothesis.

H_0 is:
"There is no difference between boys' and girls' mental arithmetic ability"

H_1 is:
"There is a difference in mental arithmetic ability between boys and girls"
(2 tailed t- test)

What if we carried out a test and p was …..

If $p > 0.05$

This is traditionally reported as:

We cannot reject H_0

OR

If $p < 0.05$

This is traditionally reported as:

We can reject Ho and accept H_1.

Note: we would state the actual p value in our writing for the reader to see for themselves what the calculated statistical test provided.

USING A STUDENT T- TEST

Use Excel

T-TEST

Quantitative data can be investigated using a statistical test known as a t-test

A t-test helps the researcher to decide if there is a significant difference between two sets of data

Once again, it involves calculating a **p value** and comparing this value to the significant level, **$\alpha = 0.05$ or $\alpha = 0.01$**

It requires the researcher to state a null hypothesis and an alternative hypothesis

The result of the test eliminates researcher bias when making any conclusions and supports the strength of any argument the researcher maybe trying to make.

https://www.youtube.com/watch?v=qvPWQ-e03tQ

T-TEST EXAMPLE

Pre- Scores	Post-Scores
34	63
56	89
21	57
15	68
19	69
28	75
27	89
32	67
67	98
45	87
81	99
45	76
23	76
53	98
42	73
49	75
37	69
48	78
24	76
36	56

The table shows the scores obtained by 20 pupils who completed a test at the start of term and at the end of term. Here are the **paired** results.

Consider the data, what do we want to test?

Pre- Scores	Post-Scores
34	63
56	89
21	57
15	68
19	69
28	75
27	89
32	67
67	98
45	87
81	99
45	76
23	76
53	98
42	73
49	75
37	69
48	78
24	76
36	56

T-TEST EXAMPLE

When carrying out a t-test, the researcher needs to ask themselves two questions.

1. Are you conducting a one-tailed or two tailed test?
2. Is the data paired or unpaired?

Are you conducting a one-tailed or two tailed test?

This depends on how open-ended your question or hypothesis is.

Is the data paired or unpaired?

Does the order matter? Are the columns linked?

1 OR 2 TAILED T-TEST?

Are you conducting a one-tailed or two tailed test?
This depends on how open-ended your question or hypothesis is.

Example of Testing hypotheses:

"I want to find out if there is a difference in mental arithmetic ability between boys and girls" (Open question, therefore a **2 tailed t-test**)

OR

' I want to find out if boys do significantly better at mental arithmetic than girls"
(Closed question, therefore a **1 tailed t-test**)

Pre- Scores	Post-Scores
34	63
56	89
21	57
15	68
19	69
28	75
27	89
32	67
67	98
45	87
81	99
45	76
23	76
53	98
42	73
49	75
37	69
48	78
24	76
36	56

T-TEST EXAMPLE

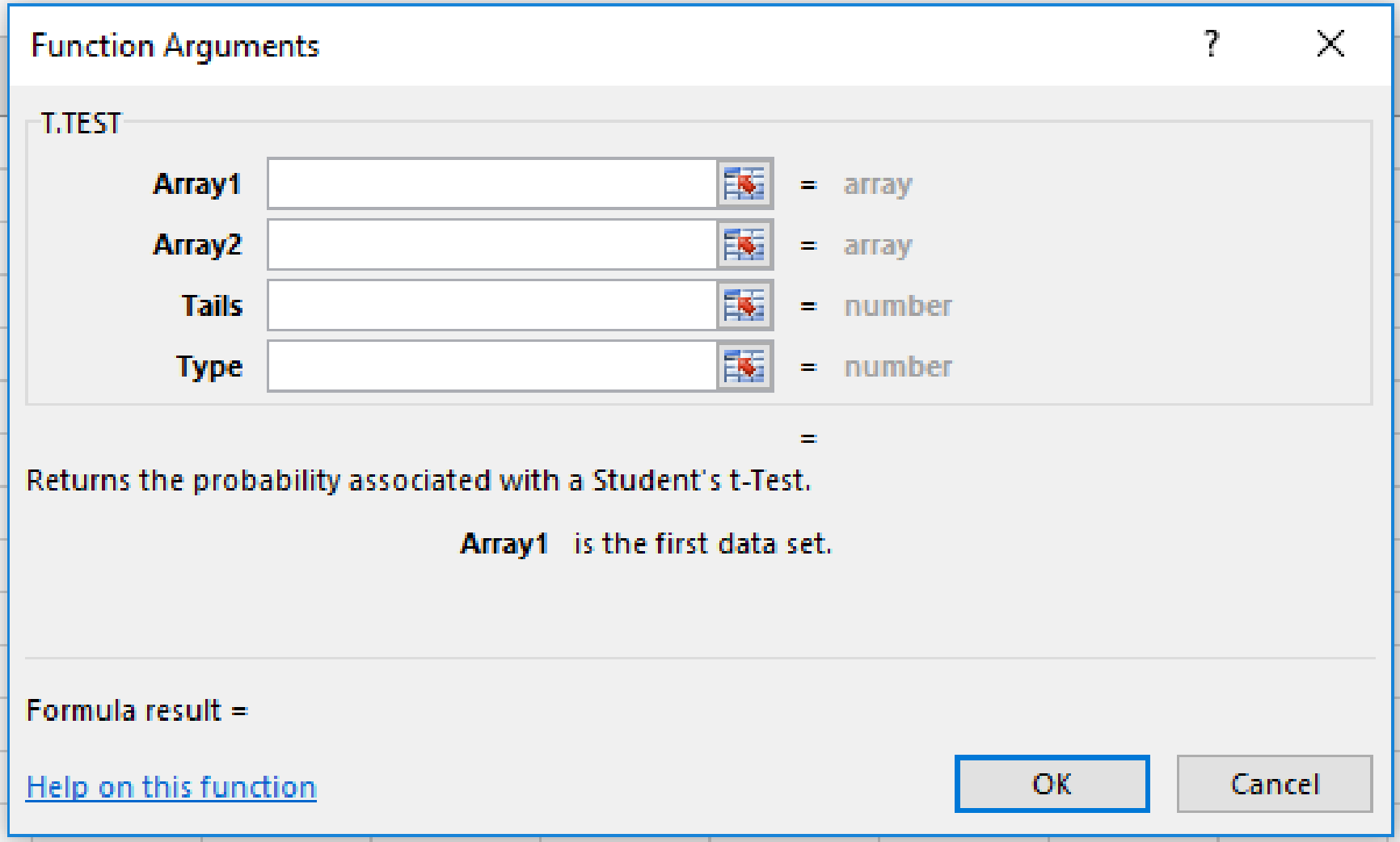
Question

'is there a significant difference between pupils' scores at the start of term and at the end of term?

When carrying out a t-test, the researcher needs to ask themselves two questions.

1. Are you conducting a one-tailed or two tailed test?
2. Is the data paired or unpaired?

1. I am conducting two tailed test
2. The data is paired



p =1.70093E-11

p =0.0000000000170093

Visit

https://youtu.be/qvPWQ-e03tQ?t=701

Question

'is there a significant difference between pupils' scores at the start of term and at the end of term?

A null hypothesis (called H_0) – states there is NO STATISTICAL RELATIONSHIP between the data.

In other words any observed relationship is most likely by chance alone

H_0 = there is **no significant difference** between pupils' scores at the start of term and at the end of term?

An experimental or alternative hypothesis (called H_1) – states there IS A STATISTICAL RELATIONSHIP.

In other words, it is unlikely that the relationship occurred by chance alone

H_1 = there **is a significant difference** between pupils' scores at the start of term and at the end of term?

$P = 0.000000000007$

Therefore $p < 0.05$, infact $p < 0.01$

So *I* reject Ho and accept H_1.

USING A CHI-SQUARE TEST OF INDEPENDENCE

Use a Chi-Square Calculator
https://www.mathsisfun.com/data/chi-square-calculator.html

CHI-SQUARE TEST

Suppose you want to know whether or not employment status is associated with a preference for a pet cat or dog

Carry out a survey
Collate the results from the survey in a table

	CAT	DOG
Employed	207	282
Not employed	231	242

Note: Categorised data

Does employment status affect pet preference?

If employment status **does** affect preferred pet we say they are **dependent.** By doing some special calculations (explained later), we come up with a "p" value:

STATISTICAL HYPOTHESIS TESTS

A null hypothesis (called H_0) – states there is NO STATISTICAL RELATIONSHIP between the data.
In other words any observed relationship is most likely by chance alone

An experimental or alternative hypothesis (called H_1) – states there IS A STATISTICAL RELATIONSHIP.
In other words, that it is unlikely that the relationship occurred by chance alone

When writing your hypothesis, you need to be specific depending on your context and what you are finding out

Define the hypotheses

'I will perform the Chi Square test of independence using the following hypotheses

H_0: Employment status and pet preference are independent.

H_1: Employment status and pet preference are *not* independent

Carry out the test to calculate p

Understanding "p" Value

"p" is the probability the variables are **independent.**

If the **p** value is more than **0.05** there is no significant relationship

If the **p** value is less than **0.05** there is a significant relationship

Let's find out

https://www.mathsisfun.com/data/chi-square-calculator.html

https://www.mathsisfun.com/data/chi-square-test.html

Chi-Square Calculator

The results are in! And the groups have different numbers

- But is that just random chance?
- Or have you found something significant?

The Chi-Square Test gives us a "p" value to help us decide.

Chi-Square Calculator

207	282
231	242

or

207 282
231 242

Chi-Square:	4.10353
Degrees of Freedom:	1
p:	0.04279

p is calculated as 0.042782

In this case **p < 0.05**,

So, this result is thought of as being "significant"

This means, we think the variables are **not** independent.

In other words, because **0.043 < 0.05** (0.043 is less than 0.05) we think that **employment status is linked to Pet Preference**

Refer back to the Hypothesis

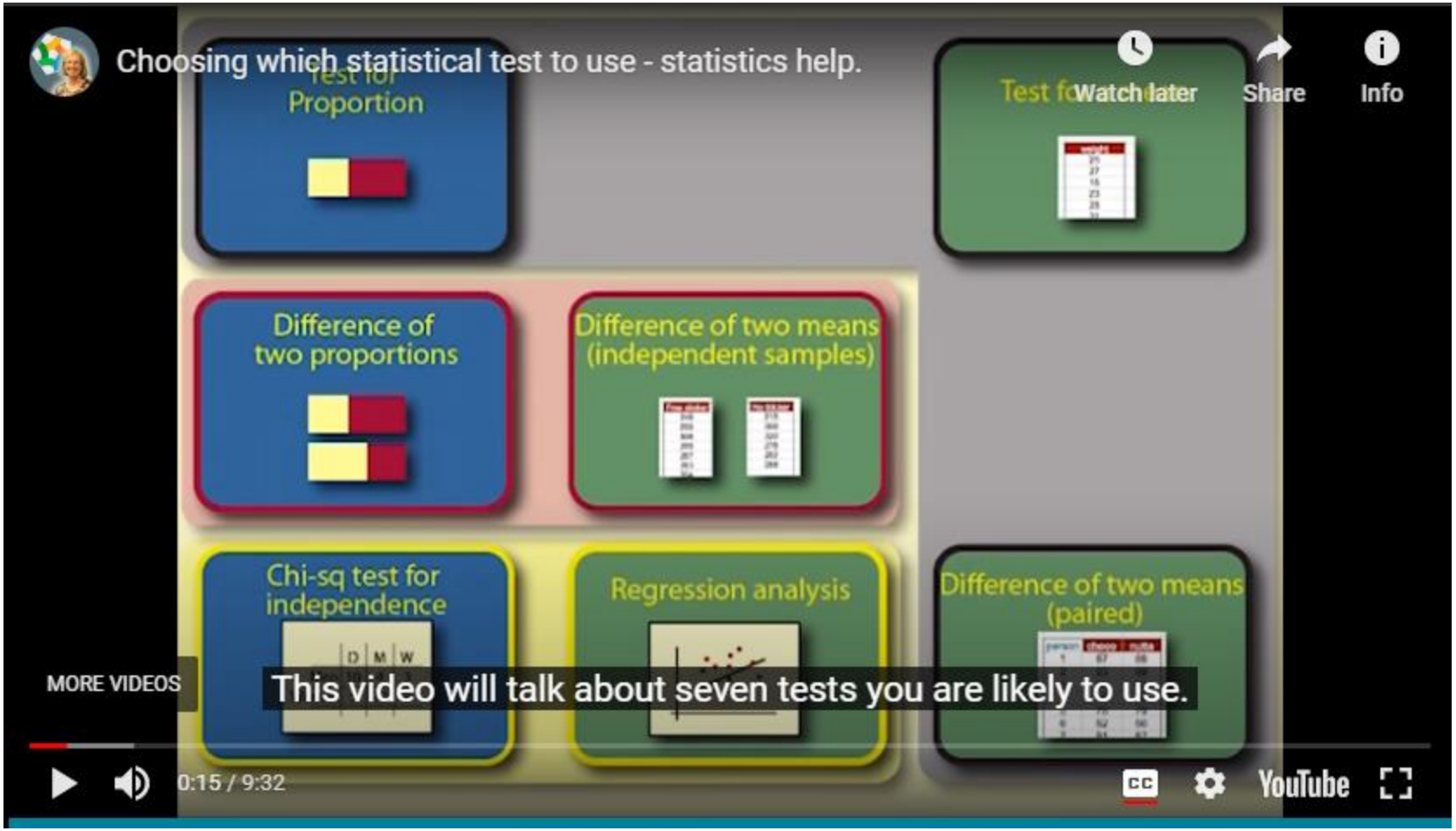
H_0: Employment status and pet preference are independent.

H_1: Employment status and pet preference are *not* independent

$p < 0.05$

We report this is as:

We reject Ho and accept H1.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