

# A suite of statistics e-Assessments with supporting materials

**Iain Weir, Rhys Gwynllyw & Karen Henderson**

CETL-MSOR 2015



University of the  
West of England

# Background

Iain Weir, Rhys Gwynllyw & Karen Henderson. *An innovative use of technology to aid the service teaching and assessment of statistics to a large cohort. CETL-MSOR 2014.*

Weir, I., Gwynllyw, R. and Henderson, K. *Using technology to inspire and enhance the learning of statistics in a large cohort of diverse ability.* IATED, ed. (2015) Edulearn15 Proceedings.

Gwynllyw, R., Weir, I. and Henderson, *Using DEWIS and R for multi-staged statistics e-Assessments.* Invited paper to be published 2015 in a special issue of Teaching Mathematics and its Applications concerning the application of Computer Aided Assessment.

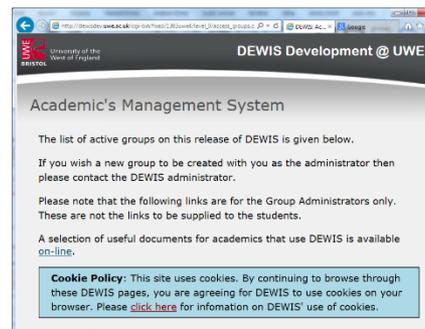
2014 Sigma Resource Development funding for a suite of e-Assessment modules that relate to the statistical activities involved in choosing and carrying out an appropriate one-sample test for location



Student



e-Assessment system



Reviewed by Nadarajah Ramesh, University of Greenwich

# e-Assessment system: DEWIS

- Can communicate with the R statistical package which was employed to generate bespoke student data and generate answers that would match SPSS screen output
- Run staged assessments
- Implement continuation marking for a large number of inputs
- Provide dynamic feedback specific to student inputs

# Motivation

This resource will benefit students from a wide range of disciplines who need to master a methodical and defensible approach to carrying in depth and appropriate statistical analysis; a variety of application contexts are offered.

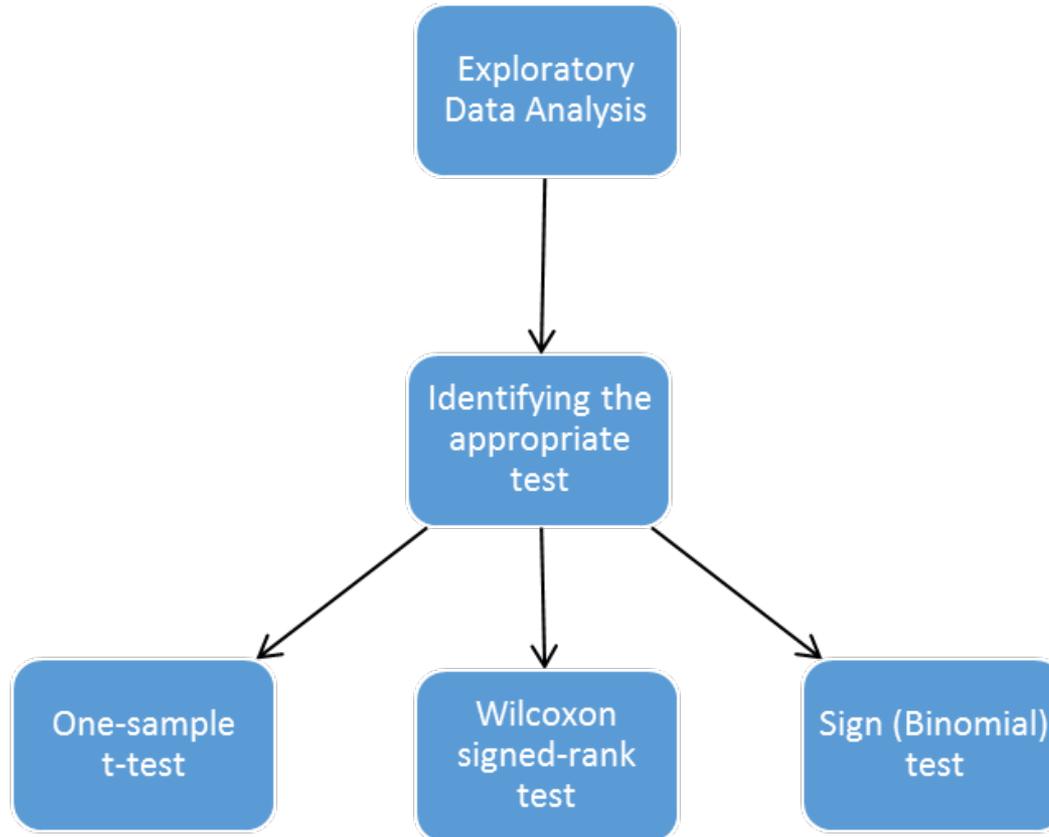
Our choice of focusing on one sample location tests is a natural one as it contains activities that are required in the extension to more complex data scenarios.

Also to showcase in public domain to encourage academics to produce further such e-Assessments using the DEWIS platform with embedded R code.

# Tests for one-sample location

- t-test for mean - assumes normality
- Wilcoxon signed-rank test for median – assumes population probability distribution is symmetrical
- Sign (Binomial) test for median

# Analysis flow



The modules can be taken sequentially which will mimic the flow of a full statistical analysis or if desired may be accessed independently.

# Choosing the appropriate test

There exist in the literature various rules of thumb for the selection of an appropriate test that consider combinations of the following properties of a sample:

- Sample size;
- Outliers (mild and extreme);
- Skewness;
- Normality.

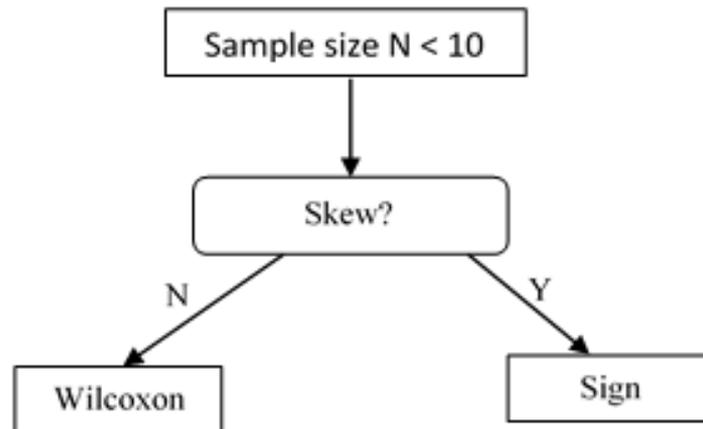
# Sample size

For this DEWIS based learning modules we shall use rules of thumb that consider the above where we have categorised sample size into the following;

- very small  $< 10$
- small 10-15
- moderate 16-29
- large 30-39
- very large 40+

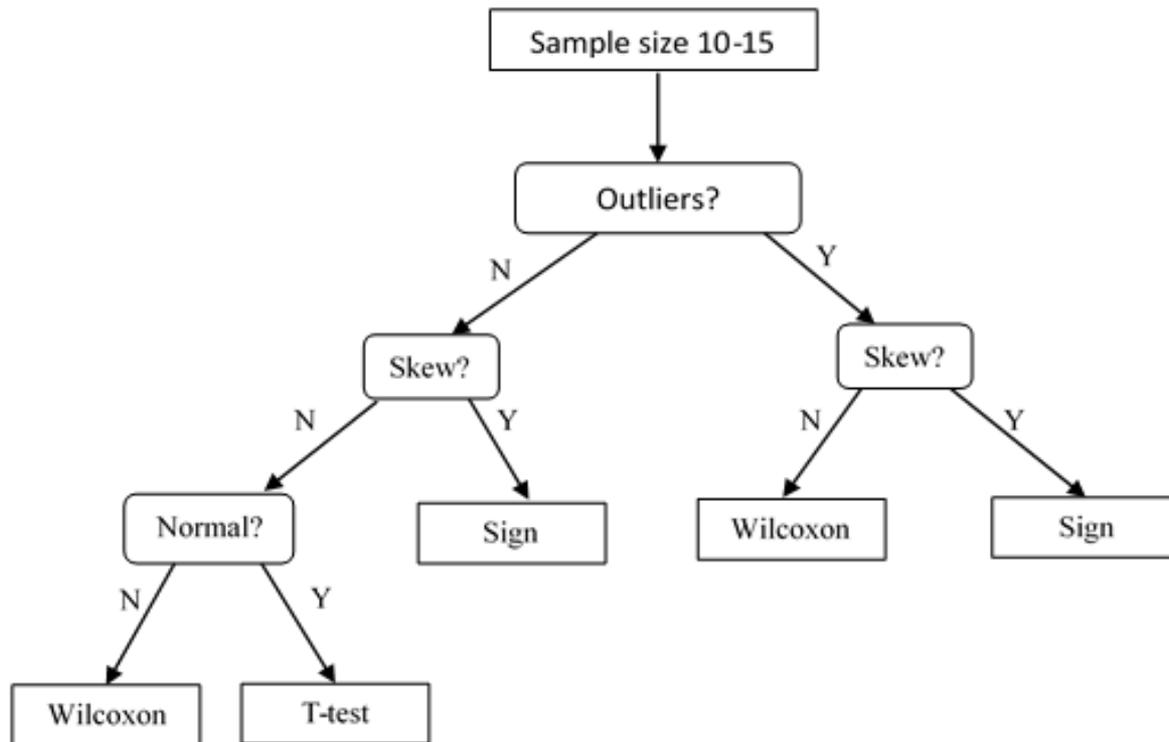
# Decision tree: very small $<10$

Normality tests cannot be relied upon and thus it is unwise to use the one-sample t-test. Considering skewness will allow you to decide between the two nonparametric tests.



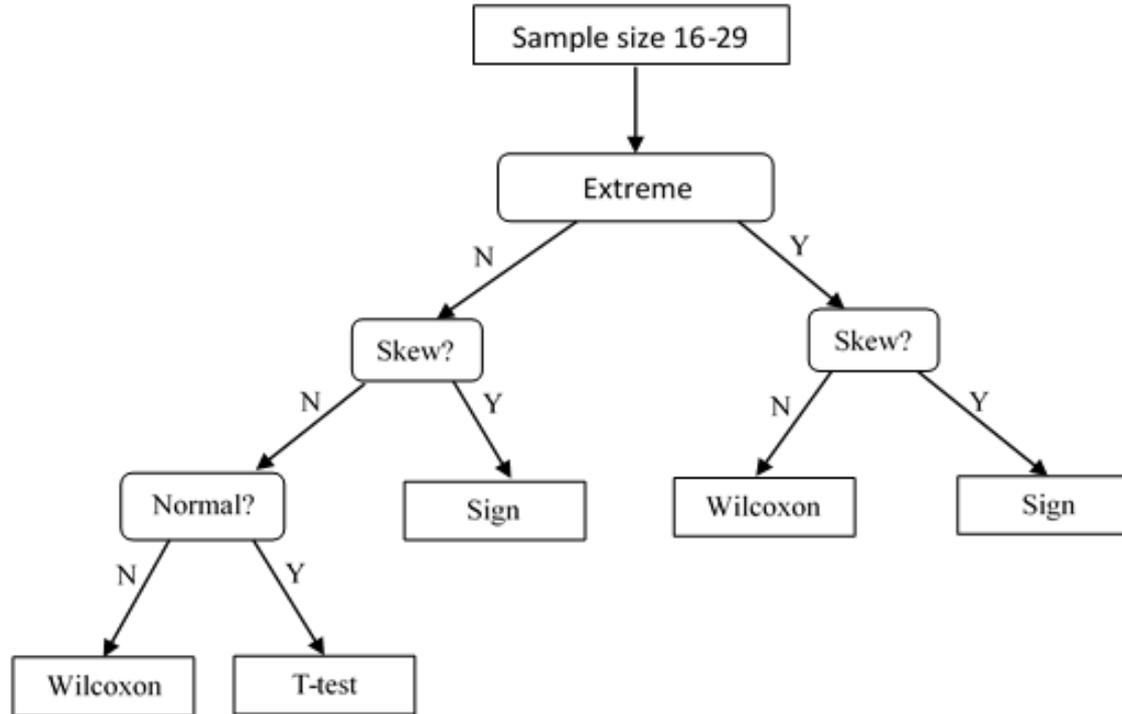
# Decision tree: small 10-15

The data set is big enough to consider the one-sample t-test. However if the data has outliers and/or is skewed it is unwise to use the one-sample t-test.



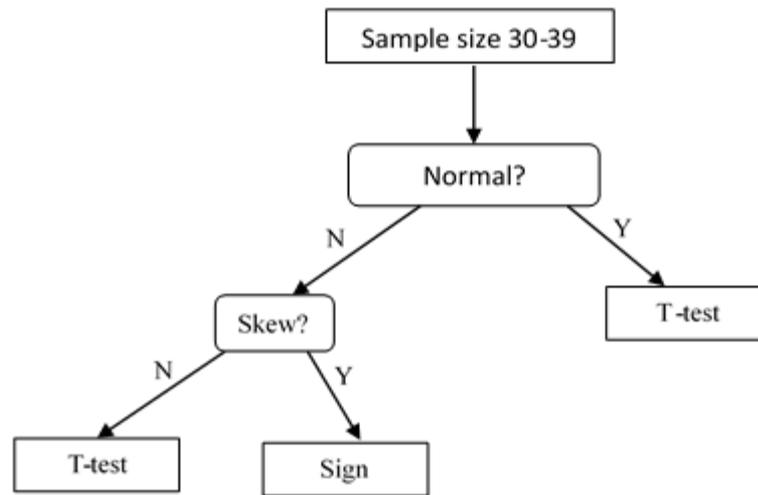
# Decision tree: moderate 16-29

If the data has extreme outliers and/or is skewed it is unwise to use the one-sample t-test.



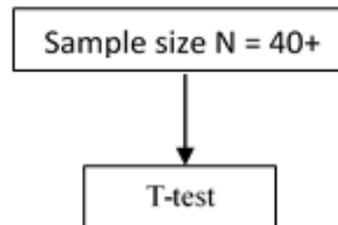
# Decision tree: large 30-39

If the data is not normal but is symmetrical it is ok to use the one-sample t-test.



# Decision tree: very large 40+

Due to the Central Limit Theorem it is safe to use the one-sample t-test regardless of outliers, skewness or failing a normality test.

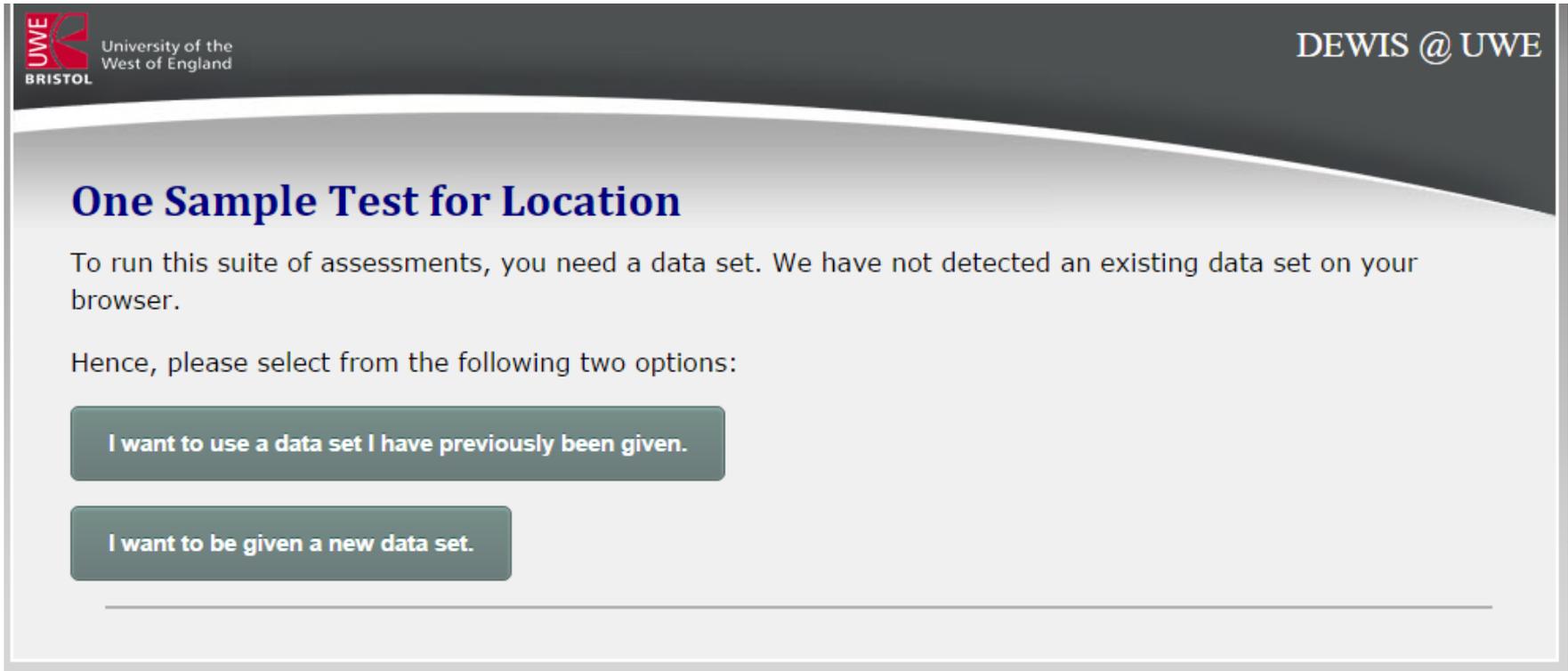




**The rest of the talk was a real time online demonstration of the e-Assessment resource.**

**The following slides briefly give some indication of what was covered.**

# Using the resource: Initial screen



The screenshot shows the initial screen of the DEWIS @ UWE resource. At the top left is the UWE Bristol logo, and at the top right is the text 'DEWIS @ UWE'. The main heading is 'One Sample Test for Location'. Below this, a message states: 'To run this suite of assessments, you need a data set. We have not detected an existing data set on your browser.' This is followed by the instruction: 'Hence, please select from the following two options:'. There are two buttons: 'I want to use a data set I have previously been given.' and 'I want to be given a new data set.' A horizontal line is visible at the bottom of the content area.

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DEWIS @ UWE

## One Sample Test for Location

To run this suite of assessments, you need a data set. We have not detected an existing data set on your browser.

Hence, please select from the following two options:

I want to use a data set I have previously been given.

I want to be given a new data set.

---

NB ability to return to carry on working with a previously given data set

# Data contexts

The screenshot shows a web application interface. At the top left is the UWE Bristol logo with the text 'University of the West of England'. At the top right is 'DEWIS @ UWE'. The main heading is 'One Sample Test for Location'. Below it, a prompt says 'Please select a context from the following menu:'. A dropdown menu is open, showing a list of contexts: 'Please select a context', 'Forest ozone level', 'Disc brake diameter', 'Weekly productivity per worker', 'Household water usage', 'Sea stars longest arm', 'Lead level in soil', 'Generator run life', 'River sediment loads', 'Soap powder packet weight', and 'Systolic blood pressure'. A button labeled 'the Front Page' is visible to the right of the dropdown menu.

Simple to add a new context by editing a R source file

# Create a question by editing a text file:

```
#####  
##### QUESTION 11: #####  
#####  
Qparas=list(  
Xcontext="", #Change  
Xmaintext="", #Change  
Xvariable="", #Change ← Question wording string texts  
Xunits="",#Change  
XnullH="",#Change  
XboxplotLabel="",#Change  
Xmean=,#Change  
Xsd=,#Change ← Mean, sd and dp for generated data  
Xdp=,#Change  
Xskew=1.75, ← Skewness and kurtosis values for non-normal data  
Xkurtosis=3.75,  
pvSmallN=0.1, ← Sample size parameters  
pSmallN=0.2, ←  
pModerateN=0.3,  
pLargeN=0.3, ←  
pNormal=.5, ← Normality and significance parameters to  
pSignificant=.5, generate different data scenarios  
Q=Q,  
iSeed=iSeed)
```

# Forest ozone example:

```
#####  
##### QUESTION 1: Forest ozone level #####  
#####  
Qparas=list(  
  Xcontext="Forest ozone level",  
  Xmaintext="A random sample was collected of ozone level readings (ppb) in a forested area in the  
            UK. Historically the average reading was 55 ppb; it is of interest to know if there has  
            been a change in average level.",  
  Xvariable="ozone level",  
  Xunits="ppb",#Change  
  XnullH="55",#Change  
  XboxplotLabel="Ozone level (ppb)",  
  Xmean=55,|  
  Xsd=9,  
  Xdp=0,  
  Xskew=1.75,  
  Xkurtosis=3.75,  
  pvSmallN=0.1,  
  pSmallN=0.2,  
  pModerateN=0.3,  
  pLargeN=0.3,  
  pNormal=.5,  
  pSignificant=.5,  
  Q=Q,  
  iSeed=iSeed)
```

# Selecting Forest ozone example:

## One Sample Test for Location

Please select a context from the following menu:

Forest ozone level ▼

Continue

Return to the Front Page

---

# Selecting Forest ozone example:

The screenshot shows a web interface with a dark header. On the left is the UWE Bristol logo (University of the West of England). On the right is the text 'DEWIS @ UWE'. The main content area has a light background with a curved top. It features a title 'One Sample Test for Location' in blue. Below the title is a paragraph: 'A data set is available with the identity 983\_01. The data set is made available when you click on any of the following modules. Please select one of the following modules.' This is followed by a vertical flow of buttons: 'Exploratory Data Analysis', 'Identifying the Appropriate Test', and three buttons in a row: 'One Sample T Test', 'Wilcoxon Signed Rank Test', and 'Sign (Binomial) Test'. At the bottom left is a button 'Return to the Front Page'.

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## One Sample Test for Location

A data set is available with the identity **983\_01**.  
The data set is made available when you click on any of the following modules.  
Please select one of the following modules.

Exploratory Data Analysis

Identifying the Appropriate Test

One Sample T Test    Wilcoxon Signed Rank Test    Sign (Binomial) Test

Return to the Front Page

NB Unique data reference number = 983\_01

# Selecting Exploratory Data Analysis module:

## Exploratory Data Analysis

### Forest ozone level

A random sample was collected of ozone level readings (ppb) in a forested area in the UK. Historically the average reading was 55 ppb; it is of interest to know if there has been a change in average level.

Not got your data set?: [Get it Here](#) [[Instructions](#)]

[Click here](#) to display the boxplot for this data.

### Exploratory Data Analysis

The sample consists of  ozone level observations that range from  to  ppb with a mean of  ppb and a standard deviation of  ppb.

The median is  ppb, the lower and upper quartiles are  and  ppb, respectively giving the interquartile range of .

The 95% confidence interval of the mean is from  ppb to  ppb. The confidence interval

include 55 ppb, thus it  look like it is a plausible mean ozone level.

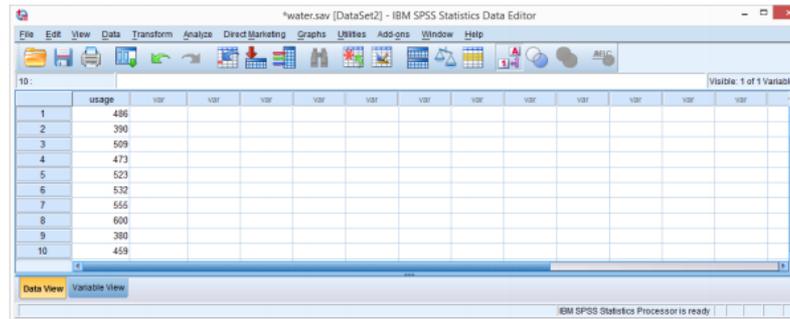
Submit



# Many help pages to click on:

## Reading in the data

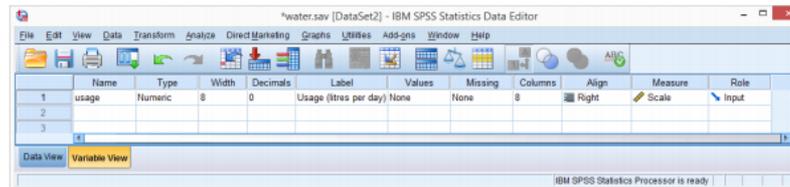
The data is entered into SPSS in one column (*usage*), the first 10 observations can be seen in the **Data View** screen shot below. Note the convention in SPSS (and most statistics packages) is that each column is a variable whose name must be a single word i.e. contain no spaces.



The screenshot shows the SPSS Data Editor window with the 'Data View' tab selected. The data is displayed in a grid format with 10 rows and 11 columns. The first column is labeled 'usage' and contains the following values: 486, 390, 509, 473, 523, 532, 555, 600, 380, and 459. The other columns are empty and labeled 'var'.

	usage	var									
1	486										
2	390										
3	509										
4	473										
5	523										
6	532										
7	555										
8	600										
9	380										
10	459										

The **Variable View** is used to assign various properties to variables.



The screenshot shows the SPSS Data Editor window with the 'Variable View' tab selected. The variable 'usage' is defined with the following properties:

Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure	Role
usage	Numeric	8	0	Usage (litres per day)	None	None	8	Right	Scale	Input

Here we can see that the following have been set up.

- The accuracy of the data is acknowledged by setting Decimals to zero. This is important as SPSS will output statistics to the appropriate corresponding degree of accuracy. **NOTE that the DEWIS Learning Modules will be expecting you to report statistics to the maximum accuracy reported when you have correctly informed SPSS of the recorded data accuracy.**
- A label has been assigned to the variable usage. This label will be used in any ensuing output and includes the units of water usage.
- The data is **Scale** data (as opposed to **Ordinal** or **Nominal**); it is important that this **Measure** is selected as SPSS then restricts you to analyses that are appropriate to the type of data you have.

# Boxplots of data are available to reassure:



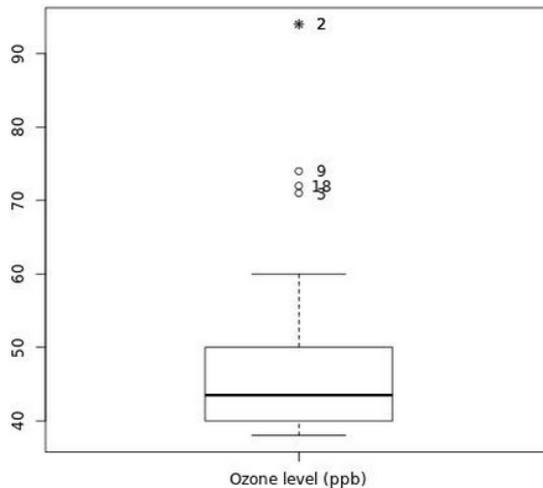
## Exploratory Data Analysis

### Forest ozone level

A random sample was collected of ozone level readings (ppb) in a forested area in the UK. Historically the average reading was 55 ppb; it is of interest to know if there has been a change in average level.

Not got your data set?: [Get it Here](#) [Instructions]

[Click here](#) to hide the boxplot.



Useful if returning to system and visually checking that supplied ref number does give the expected data!

# Some answers entered (not all correct!):

## Exploratory Data Analysis

### Forest ozone level

A random sample was collected of ozone level readings (ppb) in a forested area in the UK. Historically the average reading was 55 ppb; it is of interest to know if there has been a change in average level.

Not got your data set?: [Get it Here](#) [[Instructions](#)]

[Click here](#) to display the boxplot for this data.

### Exploratory Data Analysis

The sample consists of  ozone level observations that range from  to  ppb with a mean of  ppb and a standard deviation of  ppb.

The median is  ppb, the lower and upper quartiles are  and  ppb, respectively giving the interquartile range of .

The 95% confidence interval of the mean is from  ppb to  ppb. The confidence interval  include 55 ppb, thus it  look like it is a plausible mean ozone level.

# Poor score for my attempt!:



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## Exploratory Data Analysis

Following is a breakdown of your marks per question.

Your final score is displayed at the bottom of this page.

[FEEDBACK](#) [ANOTHER GO](#)

---

### Summary

Please click on the Feedback button to view the marking of your answers.

We recommend that you view your feedback by pressing the FEEDBACK button provided.

You also have a few other options available to you - these options will still be available if you go to the FEEDBACK.

- [Go to Learning Modules Menu](#)
- [Go to the Front Menu](#)
- [Go to the Next Appropriate Module - 'Identifying the Appropriate Test'](#)

**For this question you scored 2 out of 13.**

---

### Your result in total.

You scored 2 out of 13

**This gives you a percentage score of 15%.**

[FEEDBACK](#) [ANOTHER GO](#)

# Feedback - reminder of questions:

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## Exploratory Data Analysis

For this e-Assessment, you scored 2 marks out of a maximum possible of 13.

This gives you a percentage score of 15%.

[Go to Learning Modules Menu](#) [Go to the Front Menu](#) [Go to the Next Module \(Identifying the Appropriate Test\)](#)

### The Question

**Forest ozone level**

A random sample was collected of ozone level readings (ppb) in a forested area in the UK. Historically the average reading was 55 ppb; it is of interest to know if there has been a change in average level.

Not got your data set?: [Get it Here](#) [\[Instructions\]](#)

[Click here](#) to display the boxplot for this data.

**Exploratory Data Analysis**

The sample consists of [???] ozone level observations that range from [???] to [???] ppb with a mean of [???] ppb and a standard deviation of [???] ppb.

The median is [???] ppb, the lower and upper quartiles are [???] and [???] ppb, respectively giving the interquartile range of [???].

The 95% confidence interval of the mean is from [???] ppb to [???] ppb. The confidence interval **[does/does not]** include 55 ppb, thus it **[does/does not]** look like it is a plausible mean ozone level.

# Feedback – correct solutions:

## The Solution

The **correct answers** are as follows:

The sample consists of **32** ozone level observations that range from **38** to **94** ppb with a mean of **48.84** ppb and a standard deviation of **12.944** ppb.

The median is **43.50** ppb, the lower and upper quartiles are **40.00** and **50.00** ppb, respectively giving the interquartile range of **10**.

The 95% confidence interval of the mean is from **44.18** ppb to **53.51** ppb. The confidence interval **does not** include 55 ppb, thus it **does not** look like it is a plausible mean ozone level.

# Feedback – colour coded marking:

Correct  
Incorrect

## The Report

Your supplied answers are as follows, with the **colour green** indicating a correct answer and the **colour red** indicating either an incorrect answer or no answer:

### Additional feedback resource for creation and interpretation of SPSS output:

These resources open in a new tab/window:

- [video link](#)
- [pdf file](#)

The sample consists of **32** ozone level observations that range from **NA** to **NA** ppb with a mean of **48.84** ppb and a standard deviation of **3** ppb.

The median is **NA** ppb, the lower and upper quartiles are **NA** and **NA** ppb, respectively giving the interquartile range of **NA**.

The 95% confidence interval of the mean is from **NA** ppb to **NA** ppb. The confidence interval **NA** include 55 ppb, thus it **NA** look like it is a plausible mean ozone level.

**You scored 2 marks for this question.**

[Go to Learning Modules Menu](#)

[Go to the Front Menu](#)

[Go to the Next Module \(Identifying the Appropriate Test\)](#)

## NB links to Extra information:

- **PDF**
- **Video**

# Moving on to next module in analysis order:

## Forest ozone level

A random sample was collected of ozone level readings (ppb) in a forested area in the UK. Historically the average reading was 55 ppb; it is of interest to know if there has been a change in average level.

Not got your data set?: [Get it Here](#) [Instructions]

[Click here](#) to display the boxplot for this data.

### Identifying the Appropriate Test

#### • SAMPLE SIZE AND OUTLIERS

There are  observations in the sample of which there are  mild outliers and  extreme outliers.

#### • SKEWNESS

? Skewness =

? Std.Error =

? 2×Std.Error =

The absolute value of skewness statistic  less than 2×Std.Error.

Thus there  evidence of skewness.

#### • SHAPIRO WILK TEST OF NORMALITY

- $H_0$ : The data come from a population that  normally distributed.
- $H_1$ : The data come from a population that  normally distributed.

As  $p =$   this  significant and thus we  reject  $H_0$ ; the data  appear to come from a normal population.

The Shapiro-Wilk (S-W) statistic  give evidence of departure from normality.  
(S-W(  ) =  ,  $p =$   ).

Taking into account the sample size, outliers, skewness and the Shapiro-Wilk test of normality which one sample location test do you recommend?

Some answers entered

Module ends with test choice

# Feedback

Extra information:

- PDF
- Video

Marking colour code:  
Correct  
Incorrect

## Additional feedback resource for creation and interpretation of SPSS output:

These resources open in a new tab/window:

- [video link](#)
- [pdf file](#)

### SAMPLE SIZE AND OUTLIERS

There are **32** observations in the sample of which there are **3** mild outliers and **1** extreme outliers.

### SKEWNESS

- Skewness = **NA**
- Std.Error = **NA**
- 2×Std.Error = **NA**

The absolute value of skewness statistic **NA** less than 2×Std.Error.

Thus there **NA** evidence of skewness.

### SHAPIRO WILK TEST OF NORMALITY

- $H_0$ : The data come from a population that **NA** normally distributed.
- $H_1$ : The data come from a population that **NA** normally distributed.

As  $p =$  **NA** this **NA** significant and thus we **NA** reject  $H_0$ ; the data **NA** appear to come from a normal population.

The Shapiro-Wilk (S-W) statistic **NA** give evidence of departure from normality:

(S-W(**NA**)=**NA**, $p$ =**NA**).

Taking into account the sample size, outliers, skewness and the Shapiro-Wilk test of normality which one sample location test do you recommend? **One-sample t-test**

[Click here](#) to view the relevant decision tree choices for this data set.

You scored 3 marks for this question.

Correct

Not answered

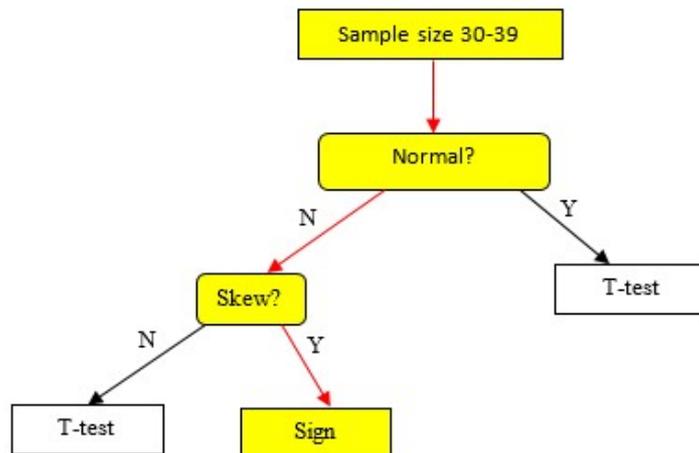
Wrong test choice!

# Feedback includes test choice decision tree:

Taking into account the sample size, outliers, skewness and the Shapiro-Wilk test of normality which one sample location test do you recommend? **One-sample t-test**

[Click here](#) to hide this decision tree.

The relevant decision tree choices for this data set is as follows:



[Click here](#) to hide this decision tree.

**You scored 3 marks for this question.**

# If desired can do not recommended test module:

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## One Sample T Test

**Forest ozone level**

A random sample was collected of ozone level readings (ppb) in a forested area in the UK. Historically the average reading was 55 ppb; it is of interest to know if there has been a change in average level.

Not got your data set?: [Get it Here](#) [Instructions]

[Click here](#) to display the boxplot for this data.

**One Sample T Test**

This is not the recommended test for this data set. With a large data set of 30-39 observations that is not normal but is symmetrical it is ok to use the one-sample t-test. However there is skewness in the data, thus the Sign (Binomial) test is recommended.

[Click here](#) to view the relevant decision tree choices for this data set.

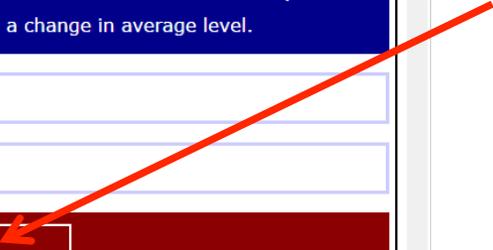
$H_0$ : The population mean ozone level  55 ppb

$H_1$ : The population mean ozone level  55 ppb

As  $p =$   we  reject  $H_0$  at the 0.05 significance level.

Application of the one-sample t-test indicates that that the population mean ozone level  statistically significantly different to 55 ppb ( $t($   ) =   $p =$   ).

NB warned this is not recommended test!



# Or do recommended test module:

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## Sign (Binomial) Test

**Forest ozone level**

A random sample was collected of ozone level readings (ppb) in a forested area in the UK. Historically the average reading was 55 ppb; it is of interest to know if there has been a change in average level.

Not got your data set?: [Get it Here](#) [Instructions]

[Click here](#) to display the boxplot for this data.

**Sign (Binomial) Test**

This is the recommended test for this data set. With a large data set of 30-39 observations that is not normal but is symmetrical it is ok to use the one-sample t-test. However there is skewness in the data, thus the Sign (Binomial) test is recommended.

[Click here](#) to view the relevant decision tree choices for this data set.

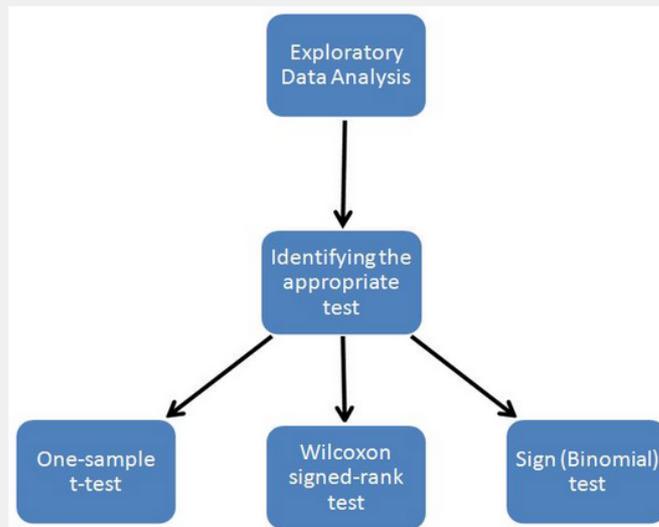
$H_0$ : The population median ozone level  55 ppb

$H_1$ : The population median ozone level  55 ppb

NB confirmed that this is recommended test

# Stand alone resources

## A suite of statistics e-Assessments with supporting materials



Videos and pdf instruction pamphlets for each module are available as a stand-alone resource and are currently available from the following links:

Module 1:	Exploratory Data Analysis	<a href="#">Video</a>	<a href="#">Pdf</a>	<a href="#">SPSS</a>
Module 2:	Identifying the appropriate test	<a href="#">Video</a>	<a href="#">Pdf</a>	<a href="#">SPSS</a>
Module 3:	One-sample t-test	<a href="#">Video</a>	<a href="#">Pdf</a>	<a href="#">SPSS</a>
Module 4:	Wilcoxon signed-rank test	<a href="#">Video</a>	<a href="#">Pdf</a>	<a href="#">SPSS</a>
Module 5:	Sign (Binomial) test	<a href="#">Video</a>	<a href="#">Pdf</a>	<a href="#">SPSS</a>

The above are also embedded in the feedback available from DEWIS in the appropriate places.

Stand-alone versions of resources that are embedded in feedback from DEWIS

- SPSS output creation PDF and video
- Interpretation video

# Further work

- Develop approach
- Employ in teaching
- Extend to other statistics tests
- Involve other people in question creation
- Other statistics resources using DEWIS + R