Example 1: (Data Set: eduproduct.txt – website)
Evaluation of a New Educational Product

Your company markets educational materials aimed at parents of young children. You are planning a new product that is designed to improve children’s reading comprehension. Your product is based on new ideas from educational research, and you would like to claim that children will acquire better reading comprehension skills utilizing these new ideas than with the traditional approach. Your marketing material will include the results of a study conducted to compare two versions of the new approach with the traditional method. The standard method is called Basal, and the two variations of the new method are called DRTA and Strat.

Education researchers randomly divided 66 children into three groups of 22. Each group was taught by one of the three methods. The response variable is a measure of reading comprehension called COMP that was obtained by a test taken after the instruction was completed.

a) Make side-by-side boxplots and an effects plot of the data. Also, make a table giving the sample size, mean, and standard deviation for each treatment group. From this information, do you think that all of the means are the same? Be sure to comment on each of the plots.

b) Examine the assumptions necessary for ANOVA. Is it appropriate to continue the analysis? Be sure to state each of the assumptions and comment on each of them using the appropriate plots/data. Remember, you need to generate the normal probability plots and histograms for each population.

c) Report the results of the ANOVA significance test (4* steps) using a significance level of 0.05. Are your results in this step consistent with part 1?

d) Use an appropriate multiple-comparison method to determine if the different types of educational methods affects reading comprehension. Explain why you chose this method. Present a graphical representation of the results if appropriate for your method. Write a short statement for your conclusion.

e) Write a short report explaining the effect of this study. Be sure to answer the question posed in this question and how far this study can be generalized. This paragraph should be written in complete English sentences and should be understandable to someone who has not taken a course in Statistics.

Solution:

data ed;
  infile 'W:\PC-Text\eduproduct.txt' firstobs = 2 delimiter = '09'x;
  input Subject Group$ Comp;
run;

proc print data = ed; run;
SAS Tutorial for STAT 350 Lab 7

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*effects plot and table of means and standard deviations;

```sas
proc sort data = ed; *again the data needs to be sorted
   the result is that the groups are alphabetized;
   by Group;
run;
```

```sas
proc means data=ed; *first calculate the averages;
   var Comp; *response variable;
   by Group; *categorical variable;
   output out=means mean=average;
   *create a file named means which has the means;
run;
symbol v=dot i=join; *to make the effects plot 'pretty';
```

```sas
proc gplot data=means;
   plot average*Group; *y = means, x = factor;
run;
```

*side-by-side boxplots are included automatically in the output, this
time, we need to create the histograms and QQplots manually;

```sas
proc sgplot data=ed;
   By Group; *to print out the histograms for each of the groups;
   histogram Comp;
   density Comp; *this adds the normal density curve;
   density Comp/type=kernel; *this adds the smoothed density curve;
run;
```

```sas
proc univariate data=ed noprint; *noprint: only thing printed are the
   requestd graphs;
   By Group; *to print out the QQplots for each of the groups;
   QQplot Comp/normal (mu=est sigma=est);
run;
```

```sas
proc glm data=ed alpha=0.05;
   *glm stands for generalized linear model;
   class Group; *categorical variable;
   model Comp = Group; *response variable = categorical variable;
   means Group /Bon Tukey; *multicomparsions by Bonferroni or Tukey;
   means Group /Bon Tukey cldiff; *provides the CI of the pairs;
run;
```

a) Make side-by-side boxplots and an effects plot of the data. Also, make a table
giving the sample size, mean, and standard deviation for each treatment group.
From this information, do you think that all of the means are the same? Be sure to
comment on each of the plots.
Solution:

Note: The side-by-side boxplots are from proc glm. The rest of the information needs to be generated manually.

From this plot, I would state that all of the means are close to being the same.

From the effects plot, it looks like B might be different from D and S, but it is hard to tell.
It appears group D is higher than the other two. Inference needs to be determine, both (c) and (d) to determine if the impressions are correct or not.

b) Examine the assumptions necessary for ANOVA. Is it appropriate to continue the analysis? Be sure to state each of the assumptions and comment on each of them using the appropriate plots/data. Remember, you need to generate the normal probability plots and histograms for each population.

Solution:

Normality:
With a sample size of $22 \times 3 = 66$, these distributions are close enough to being normal.

**Constant standard deviation**

$$\frac{s_{\text{max}}}{s_{\text{min}}} = \frac{7.3844196}{5.635781} = 1.31 < 2$$

Therefore the constant standard deviation assumption is valid.

c) Report the results of the ANOVA significance test (4 steps) using a significance level of 0.05. Are your results in this step consistent with part 1?

**Solution:**
Step 0: Definition of the terms
μ_B is the population mean COMP score for the Basal method.
μ_D is the population mean COMP score for the DRTA method.
μ_S is the population mean COMP score for the Strat method.

Step 1: State the hypotheses
H_0: μ_B = μ_D = μ_S
H_a: at least one μ_i is different.

Step 2: Find the Test Statistic.
F = 4.48

Step 3: Find the p-value, report DF:
DF1 = 2, DF2 = 63
P-value = 0.0152

Step 4: Conclusion:
α = 0.05
Since 0.0152 < 0.05, we should reject H_0.
The data provides sufficiently strong evidence (P-value = 0.0152) to the claim that the population mean values of at least one of the education methods is different from the rest.

d) Use an appropriate multiple-comparison method to determine if the different types of educational methods affects reading comprehension. Explain why you chose this method. Present a graphical representation of the results if appropriate for your method. Write a short statement on your conclusion.

Solution:

Please check with your instructor to determine which method to use.
Bonferroni:

This method was chosen because we want to compare all of the means in a pairwise fashion.

From the first 'means' statement

<table>
<thead>
<tr>
<th>Alpha</th>
<th>0.05</th>
</tr>
</thead>
<tbody>
<tr>
<td>Error Degrees of Freedom</td>
<td>63</td>
</tr>
<tr>
<td>Error Mean Square</td>
<td>39.86797</td>
</tr>
<tr>
<td>Critical Value of t</td>
<td>2.45958</td>
</tr>
<tr>
<td>Minimum Significant Difference</td>
<td>4.6825</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bon Grouping</th>
<th>Mean</th>
<th>N</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>46.727</td>
<td>22</td>
<td>D</td>
</tr>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>44.273</td>
<td>22</td>
<td>S</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>41.045</td>
<td>22</td>
<td>B</td>
</tr>
</tbody>
</table>

From means statement with 'cldiff' line
I consider the above table with A/B to be the graphical representation. What both of these tables tell us that methods D and S are the same and methods S and B are the same. Therefore the best method would be D and/or S.

Tukey:

This method was chosen because we want to compare all of the means in a pairwise fashion.

From the first ‘means’ statement
From means statement with ‘cldiff’ line

<table>
<thead>
<tr>
<th>Group Comparison</th>
<th>Difference Between Means</th>
<th>Simultaneous 95% Confidence Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>D - S</td>
<td>2.455</td>
<td>-2.115 7.024</td>
</tr>
<tr>
<td>D - B</td>
<td>5.682</td>
<td>1.112 10.251</td>
</tr>
<tr>
<td>S - D</td>
<td>-2.455</td>
<td>-7.024 2.115</td>
</tr>
<tr>
<td>S - B</td>
<td>3.227</td>
<td>-1.342 7.797</td>
</tr>
<tr>
<td>B - D</td>
<td>-5.682</td>
<td>-10.251 -1.112</td>
</tr>
<tr>
<td>B - S</td>
<td>-3.227</td>
<td>-7.797 1.342</td>
</tr>
</tbody>
</table>

I consider the above table with A/B to be the graphical representation. What both of these tables tell us that methods D and S are the same and methods S and B are the same. Therefore the best method would be D and/or S.

How to do the graphical representation by hand:
This is easily seen using the following procedure:
1) Order the means in descending (or ascending order)
2) Draw a line when the groups are the same:

\[
\begin{align*}
D & (46.727) \\
S & (44.273) \\
B & (41.045)
\end{align*}
\]

e) Write a short report explaining the effect of this study. Be sure to answer the question posed in this question and how far this study can be generalized. This paragraph should be written in complete English sentences and should be understandable to someone who has not taken a course in Statistics.

From the original question, we want to determine if the new methods D and S are better than the traditional method, B. We determined that our assumptions are correct therefore, we can look at the results of the study. These results show that method S is the same as method B (traditional method). However, it can be seen that method D is better than the original method.

When answering this question, you do need to know whether a better score or a worse score is better.