

## STEP 4: DATA ANALYSIS

As soon as the data is completed, it is time to do some type of statistical analysis. If the average data for group A is 12 and the average data for group B is 8, does this mean that the two sets of data are different? Yes, 12 is bigger than 8 – but is it statistically significant? There must be a way that shows that your original hypothesis was supported by the data.

In order to reach a valid scientific conclusion about your hypothesis you must run some type of statistical analysis. There are many different types of statistics to use. In the following pages you will find information about a variety of different ways to analyze data. Your teacher will go over some of these key ideas and help you determine what type of analysis is best for the type of data collected. You may find it necessary to contact a local statistician at a college or university to help you with your specific project.

It is critical that you use the right type of analysis and that you understand what it is that you are doing. Without statistics, you can not say that your data supported or did not support your original hypothesis. The evidence that you obtain about your data will be necessary to adequately form a conclusion about your project. Don't hesitate to ask for help on this step!

You may find from your statistical analysis that more trials are necessary. In all my years of working with science fair projects, I have never had a student collect too much data. A common problem, however, is too little data. Most statisticians agree that thirty trials are necessary for adequate use of many statistical tests.

### Assignment 12: STATISTICAL ANALYSIS

Statistical Analysis is not something that you will master in high school. It will be a continual learning experience as you learn more about how statistics can help you as the scientist to show your point. Basically, statistics can be broken down into three categories: descriptive, correlation, and inferential. All projects use descriptive statistics. These include making pictures of your data in the form of graphs and looking at trends of the data. Correlation statistics attempts to look for relationships between data sets to try to make a stronger explanation of what is happening. Inferential statistics uses mathematical principles to show proof that there is a causal relationship between the variables being tested (Blaisdell, 1993). Beginning projects will focus on the descriptive aspects. Intermediate projects should advance to the correlation level, while advanced projects will deal with inferential statistics. It is not recommended that a beginner project use inferential statistics, unless they can explain everything that was done. Parents and mentors should avoid doing the statistics for the student as most judges will be able to identify who completed and understands their own project.

#### ASSIGNMENT 12

1. To use statistical analysis to determine significance in your data.

2. To write a plan for what type of data you have collected, the type of statistical analysis you will attempt, the type of test to be used, and the level of significance that will be used to draw conclusions on your project. Remember this is a plan for what you hope to accomplish.

## Assignment 13: MATERIALS AND METHODS

The materials and methods section is the next part of the paper to be completed. Basically, this section puts your procedures into paragraph form for your paper. This section describes how you conducted your study. It will include materials and equipment used and all procedures completed. This is not a list of steps, everything should be written in sentences placed in paragraph format. NO RESULTS should be included in the methods section. Please refer to Guidelines for Preparation and Presentation of Student Research by Martin and Brenstein (1998) as a guideline.

Samples can be found in the classroom. Sample papers are included at the back of this book. Note that pictures can be very helpful in describing your procedures. The pictures may be in the text or they can be placed in an appendix at the conclusion of the paper. If pictures are included in the paper, you must refer to them at some point in the written form. It is important that you include how data was collected and the number of trials performed. If you are using a published procedure, you simply need to document the source used for the procedure. If a large amount of time was needed to engineer or build your apparatus, you may include this here. In some cases a good labeled sketch is as good as or better than pictures. You may also use a combination of pictures and diagrams.

You may include pilot studies or failed attempts if your paper is not too lengthy. This shows your ability to work through the entire problem. It is not recommended for the advanced project, however, beginners may use this to show how they solved their problem from beginning to end.

Do not use first person writing style. Do not use “I” when writing this section. Instead of saying, “I then performed three tests.” Say – “Three tests were then performed.” You may need some help from a parent or teacher to help proofread this section. This is not an easy section to complete. Avoid the long and drawn out version which includes every minor detail. However, be sure you include enough detail for the reader so that they could replicate your work.

### ASSIGNMENT 13

1. To write your procedures in paragraph form to be used in the body of the paper.

## Assignment 14: GRAPHS/TABLES

As you analyze your data, you need to find a way to display your data in a way that judges will understand. A clear table or graph is the easiest way to show a lot of data in a small space. A well-organized result section will make it easier to write your final conclusions.

All data should be displayed in chart or graph form. A data table can show a lot of numbers in a small area. You will want to be selective in the types of graphs and tables chosen and what data to include. For example, if you have 60 individual trials, you will want to include the mean results only. All of the original data will be in your data journal, which will be available at your display for judges to review. Avoid duplicating data in table and graph format unless it is extremely important to your study. In these cases you may want to put the table and graph in the same chart.

The type of graph is very important. For example, a line graph is only used when you have continuous data. Independent data points, which are not found on a continuum, should use a bar or column graph. If you were showing percents or parts of a whole, a pie chart would be best. You can include qualitative observations in a survey format if you used a survey to collect information. Be sure to check with your parent or teacher to be sure you are using the best graphs or charts for the type of data you are displaying. A good source for graphing is Students and Research (Cothron, et al., 1989).

It is recommended that you put your data in a spreadsheet such as Microsoft Excel. The following directions will help you create a chart and graphs using the excel program.

### How to Make a Chart and Graph with EXCEL (Mann, 2003)

1. Open Excel by clicking on Excel Icon on Desktop or from hard drive.
2. Click on Excel Workbook to open a blank document.
3. Enter data into cells where you want to enter your data. You can move around the Spreadsheet using the arrow keys or press enter to go to the cell below.
4. To make a column wider or a row higher you can put the cursor on the line between the columns on the top row (between letters) or between the rows on the first column (between numbers). Click and drag cursor when the plus arrow appears.
5. To change the font size, style or alignment simply click on view - toolbars - formatting. This will allow you to change a variety of formatting items.
6. To eliminate numbers and letters in the column or row headings click on file - page setup - sheet - headings or gridlines can be added or deleted.
7. To justify the numbers in the columns click on toolbar - formatting - center, left or right justify.
8. To add a function or statistics click on Fx icon - statistics - type you want (follow prompts)
9. To add a title click on view - header/footer - custom header - type title
10. To print click on file - print preview - page setup - sheet - adjust gridlines, labels, or headings - print

## GRAPHING

1. Click on Chart Wizard Symbol
2. Highlight Chart Type - next.
3. Data Range highlights the data you want included (change if it is not correct).
4. Series allows you to change names or add or remove data if necessary.
5. Click on next and then add titles
6. Click next and identify chart location - save as a new sheet to easily modify later
7. Click Finish - Print Preview - Modify or Print
8. To edit graph - double click on location you want changed
  - font change font type or size, bold, color, underline

It is important that all parts of the table or graph are clearly labeled with units used in measurements, as well as a clear title. These tables or graphs should be able to stand-alone and still be clear. These will be used in your paper as well as your display board. You will probably want to print your final copy in color, however, color is not needed in rough draft copies.

### ASSIGNMENT 14

1. To construct appropriate tables and graphs to analyze data.

### Assignment 15: RESULTS and CONCLUSION/DISCUSSION (PAPER)

Now that you have completed all graphs and tables, you need to write about your results. This section of the paper should be written in paragraph form. You should present your results of your research findings in a logical order. You must refer to tables, charts, or graphs as you discuss the data. Tables and graphs should be numbered separately and include captions and should be placed in an appendix. Numbering will enable you to refer to each graph or table in the text easily. Be sure to give a reference back to the appendix that has the graph or table.

Even though you may present your results in a graphic form, you must explain in text the important features of each table, graph, etc. This is also the appropriate place to report the results of statistical analysis of your data. Remember to report the type of statistical test used and the p value used to determine significance (usually  $p < 0.05$ ).

Once again, avoid the use of first person writing style. Rather than “My data indicates...” you should write, “The data from this study indicates...”

The next section of the paper will be the conclusion section. You need to interpret your results in this section. Begin by restating your hypothesis and explain how your data either supported or rejected your initial research questions. Discuss your research findings in relationship to what is already known about the research problem (this is found reported in your introduction section). You may want to document previous research findings to help strengthen your conclusions. Your conclusions can include

relevant, subjective observations or comments however you must state that these are speculation only.

Acknowledge any limitations, which affect the research results. Include major problems encountered. Be careful that these are problems that are out of your control, such as “the plants in the control seemed to die more than group 1”. Don’t imply that the problems were because you didn’t work or try hard enough such as “I didn’t read the thermometer correctly all the time.”

Include future experimentation plans, which are directly a result of your study. Statistical techniques used to manipulate data may have limitations. Some of the treatment effect might have been caused by a random, uncontrolled intervening variable. Again, acknowledge these limitations and other factors over which you had no control. State how these might have influenced the outcomes of the study. Possibilities for further research suggested by your study might also be presented.

Some excellent strategies for writing conclusions can be found in Students and Research (Cothron et al., 1989), Scientific Writing in Biology (Brooks and Wallace, 1995), and A Short Guide to Writing About Biology (Pechenik, 1997). You may find a variety of sources in your local library which will help you with your writing. Read samples and get an idea of what needs to be addressed in these two sections. Don’t hesitate to ask for help from your teacher. This step may involve a number of revisions to get it in its best form.

## ASSIGNMENT 15

1. To put your results of your study into paragraph form, which will be used in the final paper.
2. To write a conclusion based on the relationship between the data collected and the original hypothesis.

## STEP 4 GRADE CRITERIA

E=Excellent

S=Satisfactory

N=Needs Work

The following grade rubric will be used to assign points for this assignment:

- \_\_\_\_\_ The experiment was repeated a sufficient number of times
- \_\_\_\_\_ Data table with results clearly marked
- \_\_\_\_\_ Materials and methods are described in enough detail to be replicated
- \_\_\_\_\_ Data are presented in clear and easy to understand graphs and tables
- \_\_\_\_\_ Results section is in paragraph form
- \_\_\_\_\_ All charts, graphs and tables are referenced in the results section
- \_\_\_\_\_ Interpretations accept or reject the original hypothesis
- \_\_\_\_\_ Inconclusive findings and/or limitations of the research are identified (problem analysis)
- \_\_\_\_\_ Implications of results and recommendations for further study are identified

**Format** (Grammar, Spelling, Typed, Style) \_\_\_\_\_

**Content** (Information, Documented, Reliable, Journal) \_\_\_\_\_

**Creativity/Originality** (Ownership of Project, Ingenuity) \_\_\_\_\_

**EXCELLENT WORK: 28 - 30**

**SATISFACTORY WORK: 24 - 27**

**NEEDS IMPROVEMENT: 21 - 23**

**Total Points** \_\_\_\_\_/30 points

Suggestions for Improvement: