Typical Components Reported on a Science Fair Project/Board

Not all of these are required -- some may not be appropriate for your particular project.

And, your teacher may require some items not listed here; that's OK!

- Title
  - Clever titles are ok -- just don't let it distract from the level of your time and effort in the project
- Hypothesis
  - A concise statement about what you are testing in your experiment
- Research Question
  - This often guides the formation of the hypothesis; it could be the question you asked which caused you to begin looking into setting up your project
- Problem Statement
  - Usually for engineering projects, this outlines what challenge or task at hand
- Background Information
  - A summarized overview of work previously done that is related to your experiment
- Materials
  - Bulleted lists work well here--just identify the equipment used for the experiment
- Procedure
  - Not every single step is required, but all of the critical steps would be included here
- Diagram/Photos
  - For equipment that not everyone may be familiar with, diagrams and/or photos can be helpful
- Data Table
  - Not all of your data need to be displayed on the board (it might not all fit!), but summarized data tables can be helpful to you during the interview
- Data Analysis
  - Not every computation needs to be written out and displayed, but you should indicate what you've done to the data to formally test your hypothesis
- Graph(s) of Data
  - When possible, graphs representing your data and/or data analyses should be displayed; whether hand-drawn printout out, be prepared to answer questions about your graph
- Conclusion
  - Report your results here and indicate whether or not your hypothesis was supported by your observations and analyses
- Discussion
  - This is a place you should identify limits of your study, things you might do differently, findings that were unexpected, or ideas for further study
- Acknowledgements/References
  - Recognize those who helped you and the sources you used for your project

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Some Terminology (The Basics)

This is stuff you should look into! Knowing what these things are and applying them to your project (as appropriate) will help your project be more competitive. Keep in mind, however, that not all of these will apply to every project.

- *Green items in italics* refer to specific use of terminology that will likely catch the attention of judges in a **favorable** way.
- *Red items in italics* refer to specific use of terminology that will likely catch the attention of judges in an **unfavorable** way.

Average (or **Mean**)

The average of a set of values is a basic way to report a summary of that particular data set. It's pretty easy to determine. Add up all the values to get the sum. Divide this sum by the number of values that were added together. If you are recording a lot of measurements but only need to show a single value representative of your data, determining the average is something you should consider. Average calculator: http://www.calculatorsoup.com/calculators/statistics/average.php

- Example: You measure the heights of everyone in 5th grade, 6th grade, 7th grade, and 8th grade. One way to report the result is to find the average height in each grade. These averages could be reported in a data table of averages or a bar chart.

Bar Chart

Control Group (see **Experimental Control**)

Experimental Control (or **Control Group**)

In order to determine if the end result occurs due to a treatment (or something that was changed), you'll need to compare it to data where there was no treatment.

- Example: You are wanting to test if spraying growing oats with water in addition to regular watering will promote healthier growth than just watering the soil. To complete this test, you really should have a container of oats that you are watering and spraying with water and you should also have one container of oats that you are watering but NOT spraying with water. The second container is your control group because it is not receiving the treatment (sprayed water).

Experimental Group

Dependent Variable

Histogram

Hypothesis (see **Scientific Hypothesis**)

Independent Variable

Mean (see **Average**)

Median

Mode

Null Hypothesis (in statistics, the symbol μ_0 is used)

In a nutshell, this is a statement of what should happen if there is no effect on what you were looking at. *A statement of the null hypothesis on project boards* is rarely done, but can be very helpful for judges. It usually corresponds to nothing changing. Usually, but not always, we hope that our results can be used to *reject the null hypothesis*.

- Example: Your sister puts an ice cube out on the sidewalk. The null hypothesis is that the ice cube will not change (so it won't melt). If the ice cube melts, we reject the null hypothesis. If the ice cube does not melt, then we *fail to reject the null hypothesis*.

What are the reasons we accept or reject the null? Those are usually implied by the scientific hypothesis!

Population (N)

For a study involving humans or living organisms, this refers to all of possible subjects that could ever be included in the study.

- Example: There are 3,109,101 teachers in the United States, so N = 3,109,101. If you are doing a study on teachers, this is the total possible population.

Qualitative Data

Quantitative Data

Sample Size (n) Sometimes sources and websites use capital N

For a study involving humans or living organisms, this refers to the portion of the total population included in your study. Determining how large a sample size is needed for a study depends on the nature of the scientific hypothesis.

- Example: There are 3,109,101 teachers in the United States, so N = 3,109,101. A study you might be working on includes only 20 teachers, so *n* = 20. Avoid saying things like "*the population size for this study was _______.*" Instead, say "*my sample size was ________.*"

Scatter Plot

Scientific Hypothesis

Many people say this is an "if - then statement" or an educated guess. Like, "if my sister places an ice cube on the sidewalk, then it will melt." However, this is an incomplete view of what a scientific hypothesis is--and it is more than just a guess! Well defined scientific hypotheses are more developed than if-then statements, demonstrating a person's rationale for the expected outcome. It is OK and often helpful to begin a hypothesis with a brief informative statement.

- Example: In below freezing temperatures, ice can be caused to melt by chemical additives (like rock salt). I hypothesize that that adding dark colored sand on top of road ice is more effective than adding rock salt.
    - The null hypothesis in this case is that rock salt is just as effective as adding dark colored sand (no difference between the two). Our hope here is that our data will reject the null hypothesis, as this will be *evidence supporting our hypothesis*.
    - If we fail to reject the null hypothesis, then our *hypothesis is not supported by the data*.

If a hypothesis is not supported, this is OK! This is actually progress!! Scientists learn by discovering what doesn't work more often than being right. Avoid saying *my hypothesis was proven*. Technically, scientific hypotheses (and theories) can never be proven. They can only be disproven or supported by evidence.

Test Groups

Treatment

Trials

Uncontrolled Variables or **Mediating Factors**

Some Terminology (Advanced)

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1-Tailed and **2-Tailed Test**

When completing a statistical test on two or more sets of data, two ways you can look for a difference include "directional" and "non-directional." These are fancy ways of saying "I know which value will be greater" and "The difference could go either way." If you know which value will be greater, then you choose $p = 0.05$ to establish statistical significance--this is a 1-tailed test. If the difference could go either way, then you choose $p = 0.01$ to establish statistical significance--this is a 2-tailed test.

- Example 1: You give students a quiz on spiders before watching a video on spiders. After watching the video on spiders, you give the same quiz on spiders. You know that the quiz after watching the spider video should have a greater average than the quiz given before watching the video. So you would choose a 1-tailed test and p = 0.05.

- Example 2: You give students a quiz on spiders after watching a video on spiders. Half of the students are boys and half of the students are girls. You aren't sure which group will have the greater average. So you would choose a 2-tailed test and p = 0.01.

Correlation or **Correlation Coefficient** (*r*)

If two variables are correlated, then as one increases, the other increases. Or, as one increases the other decreases. The magnitude of *r* ranges from 0.000 to 1.000. A correlation of 1.000 is very strong. Correlations can often be noticed by just looking at a scatter plot of the data, but the value itself is determined using statistics. More detailed information: https://www.mathsisfun.com/data/correlation.html . Correlation coefficient calculator: http://www.alcula.com/calculators/statistics/correlation-coefficient/

- Example: The number of people attending a movie is very strongly correlated to the number of Twizzler packages sold.
- Notes
  - A strong correlation (*r* close to 1.000) does not mean cause and effect, but it can be an indicator of such a relationship
  - Determining and reporting *r* is a good start for competitive projects. However, by itself, scientists do not consider correlation coefficients as a definitive value to draw conclusions from.
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p-value (usually the p is lower case)

Congratulations! If you are interested in this definition, your project is likely in the top 10% of projects of the state!! This is a number generated by completing a statistical test that determines whether or not there is a statistically significant difference between two sets of data. That is a mouthful, we know. But basically, if your p-value is less than 0.05 or 0.01 (see **1-tailed and 2-tailed test**), then the statistics done to determine the p-value of your data indicate the sets of data are different and that the difference is not due to random chance. In other words, you can reject the null hypothesis.

- Example: 9 boys and 11 girls complete a quiz after watching a video. The boys' average score is 15.7. The girls' average score is 15.9. These two averages are different numerical values, but they are not statistically significantly different. In fact, the p-value is p = 0.8558. The null cannot be rejected in this case (the null would be that there is not a difference between the two test groups).
- If you want to recreate the test, the scores are as follows
  - Boys: 12,19,20,13,15,17,15,16,14
  - Girls: 14,18,20,15,14,15,15,15,13,18,18
  - Average calculator: http://www.calculatorsoup.com/calculators/statistics/average.php
  - Standard Error of Measurement (SEM) calculator: http://www.miniwebtool.com/standard-error-calculator/
  - t-test calculator: https://www.graphpad.com/quickcalcs/ttest1/?Format=SEM
- Based on the p-value of your statistical test and whether it's a 1-tailed or 2-tailed test, your results will be statistically significant or not statistically significant. Statistical tests are never *marginally significant*, *slightly significant*, or *really significant*

Statistical Significance (see also **p-value**)

Strictly speaking, statistical significance and p-value aren't exactly the same things, but they are often used interchangeably. For certain p-values of statistical tests, one can conclude that there exists a statistically significant difference between data sets. For this to actually be the case, the data must meet some basic criteria. For the level of middle school and high school science fair projects, we won't go further into details that distinguish these here. If you are interested to learn more, then you can begin by looking up "statistical power," "sample data assumptions," and "sample data assumption tests."

Statistical Test

When you have numerical data that corresponds to a control group and an experimental group; or you have two separate experimental groups and want to see if they're really different, statistical tests can help you do this. There are LOTS of statistical tests that can be performed on data sets. Usually, doing a "t-test," "paired t-test," or "chi-squared" test is appropriate for science fair projects in high school.

- Example: 9 boys and 11 girls complete a quiz after watching a video. The boys' average score is 15.7. The girls' average score is 15.9. Although these numbers are different, there may or may not be a statistically significant difference between them.
- Notes:
    - Statistical tests are not trend lines or function fits to scatter plots of data.
    - Other tests include linear regression, multiple regression, ANOVA, ANCOVA, . . . these are pretty advanced and may be necessary for fairly complex hypotheses or multiple treatments.