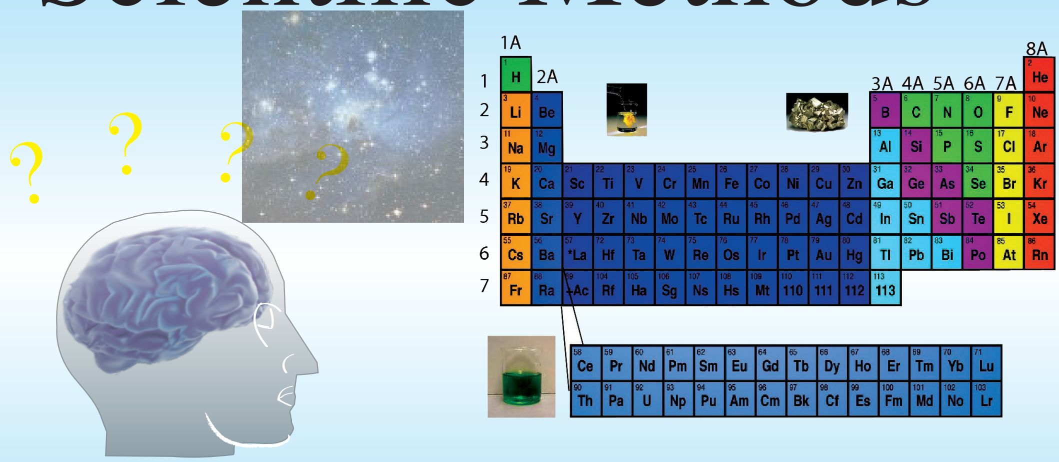
Scientific Methods



A guide to the scientific method and science projects

By

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Scientific Methods A guide to the scientific method and science projects

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Contents

The Nature of Science

Early in human history our ancestors looked at the world around them and tried to make sense of what they observed. Their observations were not made simply out of curiosity as much as survival. For warmth man needed to discover methods for making fire, to store water he needed to discover techniques for constructing containers first out of animal skins then from materials out of the Earth itself. As humans made the transition from hunter gatherer to agrarian societies they needed to develop methods for constructing permanent structures for living and storing food. Furthermore, our early agrarian ancestors studied their world in order to learn when and how to plant crops, for food, as well as the best types of crops to sustain life itself.

As time went on early humans began experimenting with the crops that they relied on for food and it wasn't long before they discovered how to manipulate, indirectly, the genetic make up of these crops in order to produce variations of plants each with its own unique properties either for nutrition, flavor, or simply for pleasure. It is also interesting to note that these early farmers also experimented with manipulating various strains of wheat and discovered that if they filtered water through bread and allowed it to ferment for a period of time they could produce a beverage with intoxicating effects. Today we call this beverage beer. Biotechnology is the science of gene manipulation for the betterment of our race and chemistry is the study of matter and its properties both of which were of vital interest to our early ancestors in there struggle to survive.

Today we have major divisions in science. Biology, chemistry, physics, and astronomy are a few of the major bodies of science that on the surface specialize in different areas of scientific knowledge while sharing a common foundation for gaining knowledge. This foundation is called the scientific method.

Scientific Method

Until around the mid 1600's people engaged in scientific inquiry without any standards for process and reporting. This means that scientists made up the methods by which they observed and collected information. Imagine going to a friends house for the very first time. Before you leave for your friend's house you ask for instructions and he/she replies, "from school walk 500 paces up main street, turn left and walk another 1500 paces. Turn right on the path by the old oak tree and walk another 57 paces and my house will be on the right." What if your friend had longer, or shorter legs than you? What is a pace and is a pace for you the same as a pace for your friend? This is the same type of problem faced by scientists up until the mid 1600's when scientists began working together and communicating their research. From this point scientists developed the methods by which they would conduct scientific inquiry and established standards of measurement leading to the duplication of results by other researchers.

Although there are many different fields of science they all use a scientific method that serves as nothing more than a logical step by step approach to problem solving. Before any problem may be solved someone must first observe and identify a phenomenon as needing to be solved.

Observation

Lets look at an example. Bob gets home from work, pops a bag of popcorn, grabs a soda and heads off to the couch for an evening of eating junk food and TV watching. Sitting on the couch Bob gets comfortable and arranges his candy, popcorn, and soda just right so that he doesn't have to move very far from his comfortable viewing position. Bob reaches over, picks up the TV remote control and pushes the power button and with great anticipation... nothing happens. Bob stuffs a handful of popcorn in his mouth and stares, in confusion, at the TV. He pushes the power button again and nothing happens. Bob makes an observation saying to himself, "when I push the power button on the TV remote control the TV does not turn on." Bob recognizes that he is facing a problem and with this observation Bob asks a question.

Questioning

Every problem, scientific or not, begins with an observation. Bob, our couch potato, observed that when he pushed the power button on the TV remote control the TV failed to turn on. Once an observation has been made a question must be asked. Questions typically come in two forms. They may be procedural referring to how something works or steps that must be taken in order to complete a task or operate a system. Causal questions deal with why things are the way they appear. Lets go back to our example.

Recall that when Bob pushed the power button on the

TV remote control the TV did not turn on. After careful consideration and much popcorn Bob asks the question, "Why won't the TV turn on when I push the Power button on the TV remote control?" This question relates directly to the cause of the TV not turning on and is therefore, a causal question. Now that Bob has asked a question he is ready to figure out the solution and get to some seriously needed TV watching.

Hypothesis

During, what was supposed to be an evening of TV watching and junk food eating, Bob observed that when he pushed the power button on the TV remote control his TV did not turn on. He then asked the question of, "Why won't the TV turn on when I push the Power button on the TV remote control?" With this question in mind Bob skims through his TV remote control users manual and then a light bulb clicks on, in his head, and he says to himself, "the TV won't turn on when I push the power button on the remote control because the remote control batteries are dead."

Notice that Bob's answer is straight forward and relates directly to the question. This answer is called a hypothesis. A hypothesis is nothing more than a possible answer to the research question. When stating a hypothesis we are relying on all of our knowledge about the problem and this is why a hypothesis is sometimes thought of as an educated guess. Keep in mind that a hypothesis, however, is far from guessing. A hypothesis must be based upon knowledge of the problem, provide a possible answer to the research question, and it must be testable.

Scientific experiments are based upon hypothesis, therefore, the hypothesis must be stated in such a way that it can be tested. When Bob stated that, "The Tv won't turn on when I push the power button on the remote control because the batteries in the remote control are dead", he phrased the question in such a way that he can easily test to see if this is the correct answer. Before a test of this hypothesis can be set up two variables must be identified.

The Independent variable is the variable that is changed or manipulated by the researcher. Often times the I.V. is referred to as the treatment. Lets look again at Bob's hypothesis. "The TV won't turn on when I push the power button on the remote control because the batteries in the remote control are dead" in this example the independent variable is the batteries because this is what will need to be changed in order to test the hypothesis. The dependent variable is what is being affected by the independent variable. In our example the TV turning on is the D.V. because changing the remote control batteries will affect whether or not the remote control will turn the TV on. With both the independent and dependent variables selected it is now time to plan out an experiment to test the hypothesis.

Experiment

An experiment is nothing more than a test of the hypothesis. Prior to planning an experiment the independent and dependent variables must be identified as they are integral components to the test. Recall that according to Bob's hypothesis the independent variable is the batteries, therefore, in his experiment Bob must actually change the batteries in the remote control.

After Bob changes the batteries within the remote control he must attempt to turn on the TV by pressing the remote's power button. The turning on, or not, of the TV is the dependent variable because this is directly affected by the batteries within the remote control. The dependent variable, in this case will be measured by direct observation.

Observing and Collecting Data

After Bob puts new batteries in the remote control he sits back down on the couch and, with great anticipation, pushes the power button on the remote control. This time Bob lucks out as the TV turns on. An actual experiment is typically much more involved than with Bob's dilemma, however, observing the affect of an independent variable over a dependent variable is simple.

During the experimental phase of a project the researcher must make careful and precise observations. Observations, no matter how unimportant they seem, must be recorded in a lab book. Formatting a lab book depends upon the experiment. Typically a lab book will contain the name of the experiment, the purpose/rationale of the experiment, all equipment used, procedures, and data tables for recording the actual observations. Once the experiment has concluded the researcher will go back through all of his/her observations in order to make a detailed analysis of the data.

Data Analysis

The final test of the hypothesis occurs during the data analysis phase of the project. Seldom does the outcome of an experiment actually conform to predicted outcomes. Therefore, the researcher must conduct a detailed analysis of the data. The type of analysis depends upon the data.

Data may be either quantitative or qualitative. Quantitative data are numerical values following standard measurement scales with equal intervals. Examples of quantitative data include measuring distances, the height of an object, mass, volume, and density. Qualitative data are data that do not follow standard scales of measurement. Examples of qualitative data include the measurement of attitudes, opinions, gender, or other genetic traits. Data analysis will be further discussed in the Data Analysis section of this book. Once an analysis of the data has been completed the researcher will state the outcome of the test.

Conclusion

After analyzing all of the data it is time to state a conclusion. Remember that the purpose of scientific inquiry is not to determine if you are 100% correct but instead to look for explanations and gain knowledge. Therefore, when stating a conclusion the researcher is simply saying that according to the data the hypothesis is either supported or rejected. In addition to stating support or rejection of the hypothesis the conclusion also contains information on which may have went wrong during the experiment, suggestions on how to improve upon the experiment, and how information/knowledge gained from the experiment may help to improve society.

Now that a method for conducting scientific inquiry has been established lets take a closer look at one of the most important phases of scientific inquiry.

Data Analysis

Analyzing and interpreting data is one of the most important skills to posses in scientific inquiry. During an experiment the researcher will observe and record data in a data table. The data from the table will then be graphed, interpreted, and analyzed for trends and relationships. The type of data collected will determine the methods by which it is analyzed.

Quantitative data

Quantitative data involve numerical values and standard units of measurement. To quantify means to measure, therefore, quantitative data include variables such as amount, mass, length, volume, and pretty much anything else you can measure based upon a standardized unit of measurement. For example a student conducting an experiment involving the affects of plant fertilizer on plant height. Quantitative data may be further broken down into continuous and discrete data. Continuous data include measurements that include partial units. The base unit for distance is the meter. The meter is continuos because it may be divided into smaller or divided into larger units. Discrete data include variables that may only be measured in whole numbers. Counting the number rabbits found in a given area or the number of people with blue eyes are examples of discrete data.

Quantitative data are further divided into ratio and interval data. Ratio data are measured using standardized scales with an absolute zero. Measuring temperature on the Kelvin scale is a type of ratio data due to the fact that on the Kelvin scale absolute zero represents a complete lack of energy within a substance. Interval data are measured using standardized scales that do not have an absolute zero. Water freezes at 0^{o} Celsius and boils at 100^{o} degrees Celsius. Even at 0^{o} Celsius the molecular motion of water does not cease. In order for all molecular motion to stop, within water, its temperature must be lowered to -273^{o}Celcius.

Qualitative data

Quantitative data are grouped into categories. Data within these categories may be either labeled or collected using non standardized units of measurement with unequal intervals. Examples of qualitative variables include gender traits and opinions whose categories are determined by the researcher.

Qualitative data that are rank ordered are called Ordinal data. Ordinal data include opinions where a value of 1 means no opinion and 10 means very strong feelings towards or against something. Moh's hardness scale provides a method for qualitatively identifying minerals. Nominal data include variables that are placed into discrete categories that can not be rank ordered such as gender, hair color, and shape of face.

Measures of Central Tendency

Once data has been gathered the researcher will need to test any relationships between independent and dependent variables. To do this the researcher will test the measure of central tendency which refers to the number/s that are most common to a data set. Researchers will also test the variation which describes the distribution of the data. The measure of central tendency that is used will depend upon the level of measurement in the study. There are three measures of central tendency which are used based upon the type of data being collected.

Mean

The mean is the statistical average of a data set and may only be used with interval or ratio data. To calculate the mean simply take the sum of the values and divide it by the total number of cases from which the data set was gathered. For example, a student wants to know what his grade in science is. In order to calculate his grade point average he gathers all of his grades from the current grading quarter:

During the current quarter our student completed a total of five assignments each worth the following points: 30+10+10+20+40=110points possible. Following is a breakdown of what our student earned from each assignment: 25+10+10+15+36= 96 point earned. Out of 110 points he earned 96. So how does he calculate his grade point average, or the statistical mean? By taking the total of what our student earned then dividing by the total points possible he gets a value of 0.87. In order to convert this decimal

$$\frac{25+10+10+15+36}{110} = \frac{96}{110} = 87\%$$

number to a percent he then moves the decimal two places to the right and smiles at the realization that he is earning an 87% in class.

Lets take a look at another example. During a study to determine the efficacy, effectiveness, of plant fertilizer when compared to the height of plants researchers gathered data on six plants and measured their heights in centimeters:

6, 4, 3, 5, 9, 7

To calculate the mean for plant height all values must be added together then divided by the total number of plants as follows. In this case the sum for plant height is 34 centimeters divided by six plants giving us a mean plant height of 6 centimeters.

$$\frac{6cm+4cm+3cm+5cm+9cm+7cm}{6} = \frac{34}{6} = 5.6$$

Median

There are two methods by which the median is found depending upon how many values are in the data set. The median value is simply the value that falls in the middle. If there are an even number of values in the data set the median is determined by taking the sum of the two middle values then dividing by two. If there are an uneven number of values the median falls directly in the center with half of the values falling above and half below. Below are examples for each.

In a study where researchers are testing the efficacy of a new type of plant fertilizer against plant height they gather the following data on six plants. Plant height in centimeters: 6, 4, 3, 5, 9, 7

In order to determine the median for plant height these values must first be ordered from largest to smallest:

9, 7, 6, 5, 4, 3

The median value is the value that falls in the middle which means that half of the values fall above and below the median. Median data may be used with ordinal, interval, or ratio data but not nominal data because nominal data, once again, are not measured on standardized scales. Therefore, the median for our data set is as follows:

9, 7, 6, 5, 4, 3=5.5

We get this by adding the two middle values together then dividing by two. We use this method when our data set contains an even number of values. If a data set contains an uneven number of values simply take the one that falls in the center after all values have been arranged from highest to lowest value. Let's look again at the same data set except this time we will add one more to the list:

Plant height in centimeters:

10, 9, 7, 6, 5 ,4, 3= 6

In this instance six is the median for plant height because there are three numbers above and three numbers below it.

Mode

Mode is a measure of central tendency referring to the variable that occurs most often and may be used with ordinal, nominal, ratio, and interval data. When calculating the mode of a data set there may be two values that occur most often. In this case both values are reported as the modes. Below are examples of data sets where the mode is being determined.

9	15	27
7	13	25
6	12	19
6	11	19
5	6	15
4	4	10
1	4	10
Mode= 6	Mode=4	Mode=19 and 10

Each measure of central tendency has its strength and weakness. During a study it is important to determine which to use depending upon which type of data has been gathered. The mean, median, and mode may be calculated for ratio and interval data. Out of the three the mean is the strongest measure of central tendency and is usually used for ratio and interval data. If a data set has values that are either very small or very large compared to the rest of the data they may skew the mean and cause an incorrect analysis of the data. In such cases the median or mode is used in place of the mean. Compared to the mean the next strongest measure of central tendency, for ordinal data, is the median, however, the mode may also be used. The mode is typically used as the measure of central tendency for nominal data.

Measuring variation

Most people are familiar with calculating measures of central tendency. Grade point averages, batting averages, average number of students in a classroom, and average hair and eye color are all measures of central tendency. In data analysis variation is also used to look for relationships between the independent and dependent variables. Variations within variables are measured in one of two ways. The **range** is calculated by taking the difference between the largest and smallest measures of the dependent variable when data is gathered quantitatively. Lets look back at the example of plant fertilizer versus plant height. The first step is to order all values from largest to smallest then take the difference between the largest value and smallest value as follows:

Plant height in centimeters: 9, 7, 6, 5, 4, 3= 9-3=6cm

There is a variation of 6cm between the largest and smallest plants.

So why is the range of values important? This is the question students, quite possibly, do not ask when learning how to calculate the range for a data set. Lets say we have two groups of plants in our study each with equal means:

Group 1 (plant height in cm): 9, 7, 6, 5, 4, 3

Group 2 (plant height in cm): 10, 7, 6, 5, 4, 2

The mean for Group 1 is 6cm and the mean for Group 2 is also 6cm. Both are different groups with the same means but are they identical? Then range in plant height tells a different story. The range in plant height for Group 1 is 6cm and the range in plant height for group 2 is 8cm. The plants in Group 2 show a greater variation in plant height. It is this variation that must be considered when evaluating the efficacy of the independent variable.

When working with qualitative data frequency distribution is used to show variations within a data set. **Frequency distribution** shows the number, value, for the number of cases that occur within each variable. Lets say a student decides to conduct a study in order to determine which genetic trait occurs most often among ninth grade students. During her study she looks at the following traits:

Genetic Traits among 9th graders	
Mode	Earlobe attachment and cleft chin
Frequency distribution:	
Tongue curl	34
Earlobe attachment	17
Dimples	10
Nostril flare	22
Cleft chin	17
Number of students	100
Expected frequency	100/5=20

From the data table you can tell that the mode, or most commonly occurring trait, is both earlobe attachment and cleft chin. Her frequency distribution shows the number of students with each genetic trait and the total number of students in the study. At the bottom of the data table is another value called the expected frequency distribution. The **expected frequency distribution** will be important when testing the hypothesis against the data. The expected frequency shows the number of cases that the researcher would expect to occur within each variable. In this case the researcher tested 5 variables on a total of 100 students. To calculate the expected frequency simply take the number of students and divide it by the number of variables. By doing this the researcher would expect to find, in a perfect world and all things being equal, each trait would occur 20 times.

When determining which measure of central tendency and variation to use in the analysis of data use the following chart as a guide:

Data Type	Quantitative	Qualitative	
	Interval or Ratio	Nominal	Ordinal
Central tendency	Mean	Mode	Median
Variation	Range	Frequency distribution	

Review

Calculate the mean, median, and range for the following data sets:

1. 92, 6, 22, 72, 85, 37, 6, 85, 34

Mean: ______ Median: ______ Range:_______

2. 43, 2, 3, 43, 71, 85, 62

Mean: ______ Median: ______ Range:_______

3. –14.8, -3.4, 17.2, 20.4, -26.9, -3.4, 8.9, -18, -22.7, -0.2

Mean: ______ Median: ______ Range:_______

4. –4.5, -34, -7, 21.8, 6.3, 52.8, -79.04, 32.5, -10.5, 6.3, -4.5

Mean: ______ Median: ______ Range:_______

5. Given the following Prices of used homes (in thousands)

101.5	111.5	142.7	183.7	150.3	189.9
109.3	166.7	54.9	178.7	108.7	110.2
117.9	107.9	178.2	53.8	65.5	58.7
85.3	137.5	145.3	123	128.6	103.5
169.5	113.4	51.6	108.9	146.8	95.3

Mean: ______ Median: ______ Range:_______

Use the following data table for questions 6 and 7

Table 1. Plant height in cm

Mean height	?
Range in height	?
Maximum height	18
Minimum height	7
Number of plants	5
Plant 1	7
Plant 2	5
Plant 3	3
Plant 4	10
Plant 5	4

6. What is the mean plant height?

7. What is the range in plant height?

Use the following table to answer questions 8 through 10.

Table 2. Flower color

Mode Frequency Distribution:	Expected Frequency	
Yellow	10	
Red	25	
Orange	40	
White	25	
Number of Plants	100	

8. What is the mode for flower color?

9. Explain the frequency distribution of flower color from the table.

10. Calculate the expected frequency from table 2.

A Guide to Science Projects

The following pages are provided as a guide for students during the conduct of a scientific project. This guide provides students with step by step instructions that should be used in conjunction with what they are being taught in the science classroom

Topic Selection

This is one of the most difficult things about doing a science project. Keep in mind as you are picking a topic that you will have to live with it for about until you are finished. Once you choose an idea that you like, spend a few quiet moments thinking about how the whole project would work. If you can imagine obstacles that will be too difficult, then find a new topic. Don't forget the cost of supplies and time constraints.

Sometimes the most interesting projects come from things that you like to do in your spare time. Think of your hobbies, sports, clubs, chores at home, etc. Is there some aspect of these that you could measure and test?

Refer to science project books in the library or ideas on the Internet. You will probably have to expand or change an idea in order to make it into a measurable and experimental project.

In the space below, describe in one paragraph what you would like to do for a science fair project.

MY TOPIC:

Problem Statement

The next step is to turn your topic into a problem statement for the project. The problem statement is a sentence or question that identifies the independent variable and the dependent variable. More often than not the problem statement will be in the form of a question. This question will either be causal or procedural depending upon the topic chosen for the project.

Independent variable: The variable or factor that you decide to change; the cause

Dependent variable: The effect that you measure as a result of the independent variable

Example: How does the amount of water affect the height of plants?

Independent variable:	Amount of water (L)
Dependent variable:	Height of plants (m)

Notice in the example that both the independent and dependent variables are measurable. Amount of water is measurable in liters and height in meters.

Think about your topic and imagine a few possible independent and dependent variables that you could use. List them below.

Independent Variables **Dependent Variables**

Now choose one from each list that will work well together and that you find most interesting. Write a problem statement including these as your independent and dependent variables for the project.

PROBLEM STATEMENT:

Research Explanation

When you do research, you want to find articles and books that can teach you something about the independent and dependent variables of your project. Learn about the topic so that you can make a hypothesis in the next step based on intelligent information. Your conclusion will have to be related to what you learn about the variables now and how they turn out in your experiment. Therefore, the research is the foundation of a good hypothesis and a meaningful conclusion.

A typical science project will have at least 4 sources:

1 PERIODICAL (journal, newspaper, magazine)

2 BOOKS or additional PERIODICAL that is different from the one you already chose.

1 OTHER (encyclopedia, Internet, interview with an expert in the field, book, periodical, etc.)

Come up with keywords for your research. Use your independent and dependent variables, any words or phrases related to them, or synonyms. When conducting an online search for information on your topic you may want to use search engines such as Google, Ask.com, or Discoveryschool.com. When you type in your search words in a search engine you will get many hits. Be careful about using information from .com web sites as their information is not typically regulated and has a higher probability of being incorrect. There will be nothing more disappointing, upon completion of your project, to find out that you have based your hypothesis upon incorrect information. For this reason it is suggested that you stick with .edu, .org, and .gov web sites as they are typically regulated

KEYWORDS:

Source 1 - Book

Title:

Author/s:

Publishing company:

City where it was published:

Date of publication:

Page/s you used:

Rewrite the information above in the correct bibliographic format. This information should be provided by your science teacher as schools may differ on how this is taught.

Bibliography:

Two things learned from this source:

1.

2.

Source 2 - Periodical

Title of periodical:

Title of article:

Author(s):

Volume number of periodical:

Date of periodical:

Page(s) of article:

Rewrite the information above in the correct bibliographic format. This information should be provided by your science teacher as schools may differ on how this is taught.

Bibliography:

Two things learned from this source:

1.

2.

Source 3 - Book or Periodical

Title of book/periodical:

Title of article:

Author(s)

Publishing company:

City of publication:

Volume of periodical:

Date of publication:

Page(s):

Rewrite the information above in the correct bibliographic format. This information should be provided by your science teacher as schools may differ on how this is taught.

Bibliography:

Two things learned from this source:

1.

2.

Source 4 Internet

If this source is a book or periodical, see the previous pages for the kind of information necessary. If it is an Internet source, obtain the information below:

Internet source

Title of article:

Author(s):

http:// address:

Date of document or date downloaded:

Bibliography:

Two things learned from this source:

1.

2.

Parenthetical Documentation

When you write research papers of any type it will be necessary for you to use the ideas of others to support your own views. There are three different ways that you can use the ideas of other people:

1. Summarizing
2. Paraphrasing
3. Quoting directly

All of these examples require you to acknowledge that the ideas or words are not your own. Whenever you write something you must identify which ideas are not your own and indicate where they came from. People reading your paper must know when things you write are not your own thinking and how to find the original source if they need to find it. (Evans, 1998)

Summarizing:

When you summarize the major point, the general position, or an overall argument by an author, then a reference to the work as a whole without a page number is okay.

Paraphrasing:

A good way to use another author's words is to take their ideas and put them into your own words. In this way you can put emphasis on the parts that relate to what you are studying. You need to make sure that your paraphrase is accurate. (Evans, 1998)

Paraphrasing should be in your own words. You cannot paraphrase by taking sentences or phrases and just changing a few words - that is plagiarism. Paraphrasing works best if you read the whole section you wish to refer to several times until it is clear to you. (Evans, 1998, p. 2).

Quoting Directly:

Quoting directly is using the author's exact words. You should only do this if the author has a very exceptional way of stating something. A good thing to do is paraphrase most ideas and use one or two direct quotes to capture something an author said. Direct quotes should be in quotation marks unless the quote is longer than 3 lines, then it should be indented without quotes.

Parenthetical Documentation

Examples:

(Evans, 1998) - a summary - no page number necessary.

(Evans, 1998, p. 2-3) - a paraphrase - need the page numbers.

(Evans, 1998, p. 3) - a direct quote - need the page number.

(Source: Evans, DR., Rossman, G.B. (1998). Using the work and words of other authors: A short guide to using APA guidelines. Massachusetts: University of Massachusetts.)

Plagiarism

PLAGIARISM is considered a serious offense. Students, like other writers, are expected to acknowledge the work of others and to assist their readers in finding specific locations from which their ideas are drawn. In other words, if you are summarizing, paraphrasing, or quoting another person, you need to attribute that material to its source. You may be taking the information from an interview or other oral text, or from the Internet, or from the conventional printed text. In either case, the source MUST be documented. Just remember this saying, "when in doubt... Quote somebody" because plagiarism carries serious penalties.

Research - Written Summary

After completing the research, you must summarize what you have learned about the independent and dependent variables in 2-3 paragraphs. Reread the notes you took. Organize the information in a logical way; don't just list in order what each source told you. Think of this as a mini-report about your variables.

Pay attention to grammar, spelling, and sentence structure. Do not use the 1st person (I, we, my, etc.). When writing a research report use third person and refer to yourself as the researcher or student. Writing in third person may seem rather boring and your paper may even put you to sleep, however, science papers are about the facts, nothing but the facts so don't try and make it interesting with flowery adjectives just keep it impersonal and stick to the facts. Make sure you also use introductory and concluding sentences.

Hypothesis

After learning about the independent and dependent variables, you must make an hypothesis about how the experiment will turn out. The hypothesis is one sentence that states what you think the answer to the problem statement will be based on what you learned in the research. The sentence should indicate what you expect the dependent variable (effect) to be as a result of changing the independent variable (cause).

The hypothesis should not be written in 1st person (I, we, my, etc.). Try using one of the formats below for writing your hypothesis, or adapt one of them so that you don't end up saying "My hypothesis is…" And remember the hypothesis is not a guess. The hypothesis is a probable answer to your research question or problem statement.

1. It is hypothesized that there is a direct relationship between ____________________ and _______________.

2. The hypothesis for this research project is that ________________________ will cause a significant change in _____________________.

3. It is hypothesized that _______________will result in _______________.

WRITE YOUR HYPOTHESIS:

Organizing and Planning Your Project

In order to make sure you know what you're measuring, how you are going to measure it, and how you will set up your experiment, fill in the following worksheet.

1. Independent variable:

   Units of measurement:

   Instrument/tool for measuring:

2. Dependent variable:

   Units of measurement:

   Instrument/tool for measuring:

3. List all factors that must remain constant and explain how you will keep them constant.

4. Describe the control group.

5. If you are using plants, list their scientific names.

Experiment - Materials

List all materials, supplies, equipment, tools, etc. that you will need for this project. Add or delete things from this list later when you perform the experiment so that the list you include in your final project is correct.

Typically, if you are using chemicals or plants, those things should be in a separate list next to the equipment.

Experiment - Procedure

Write a list of all the steps you will need to follow to run the experiment. Another person should be able to follow your procedure without ever having to talk to you, so make it good. Although the procedure can be written as a numbered list or a paragraph, at this stage it is probably better to write it as a list so you can make changes as you go along for the final draft. You might want to set up the front and back of this page in two columns: one for the planned procedure and one for the actual procedure that you followed.

Record and Analyze Data - Data Table

You must have a data table drawn before you experiment so that you have a place to record your observations neatly. It is difficult to draw one sample data table as an example, since yours will depend on the type of experiment you choose, but the one below may help you get started.

Guidelines:
1. Label each data table with a number and title.
2. Each column should have a heading with units if appropriate.
3. All 3 trials for each group should be shown.
4. The average for the trials in each group should be calculated.

Sample data table showing the amount of water, trial results and the statistical mean.

Amount of water	Trial 1	Trial 2	Trial 3	Statistical Mean

Sketch your data table in the space provided and use it as a rough draft for your experiment.

Record and Analyze Data - Graph

Guidelines:

1. Use graph paper or a computer.
2. Decide whether a line graph or a bar graph is better for your data.
3. Label the top of the graph with a number and title that includes the dependent variable first and the independent variable second along with units of measurement
4. Label the x-axis with the independent variable and its units.
5. Label the y-axis with the dependent variable and its units.
6. Number the axes appropriately. Label the individual bars appropriately.
7. Indicate the relationship between the variables.

Conclusion

The conclusion will be another mini-report that summarizes the experiment and relates it to the research and hypothesis. In addition, you need to think about how the experiment might be improved upon. Before writing a rough draft of your conclusion, fill in the information in each area below. These are the things that you will then organize and summarize in the conclusion.

1. What was the answer to the problem statement?

2. Was your hypothesis supported or not?

3. Depending upon the type of data collected list the statistical mean, median, or mode that will defend the answers to questions 1 and 2 above.

4. List at least 3 errors that might have happened and explain how they affected your results. (Do not include "I might have written down the wrong number," or "I might have calculated

5. What could be done differently if you repeated this experiment (either to minimize errors or help clarify your results)?

6. What is the importance of this experiment? What impact could the results have?

Use the answers for the questions on the two previous pages to write your conclusion. A good format might be to write one paragraph about questions 1, 2, and 3, a second paragraph about questions 4 and 5, and a third paragraph about question 6.

Bibliography

Write all of your sources in the correct bibliographic format in alphabetical order by author.

Poster Design

_____ Find and organize all of the information and materials for the project.

_____ Neatly recopy (using a computer) each of the written parts of the scientific method onto its own sheet of paper. Use large, clear lettering that can be read by people as they pass by your project.

_____ Get a piece of display board to attach your papers and pictures to.

_____ Write a title at the top of the board.

_____ Before you attach anything, arrange the papers of your experiment on the display board to see how they look. They should be in order of the scientific method. Once you are satisfied, attach them neatly to the board. Feel free to have a colorful background. Use some creativity. Your poster should be eye-catching.

_____ Set up other equipment in front of your poster to see how it looks.

_____ Make a sketch of your poster below to serve as a template for when you make the actual display

Oral Report Guidelines

_____ Prepare for your presentation by reviewing each part of the experiment so that you know it well. Review your research so that you can speak intelligently about your topic.

_____ Think about the following questions:
What were your results?
Why did you choose this project?
What was the hardest part (or easiest)?
What were the one or two things you learned?
What would you do differently next time?
Why?

_____ Use note cards for your presentation. Do not read from your poster.

_____ Practice your presentation before you actually present.

_____ Prepare a 2 - 4 minute introduction of your project.

_____ Speak slowly, and do not chew gum. Take a deep breath if you get confused.

_____ Explain how you tested your hypothesis.

_____ Review your major findings.

_____ Discuss your conclusions.

_____ Prepare a 1-2 minute conclusion to your presentation.

_____ Ask if there are any questions.