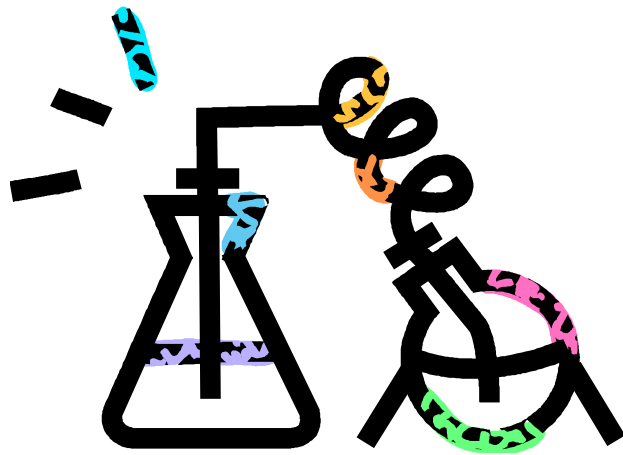


INVESTIGATING



SCIENCE

A guide to conducting independent
high school student research

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Overview of the Research Process

Goals: To develop critical thinking skills by forming a question and solving a problem; To learn to organize information and develop new ideas; To work with a partner for a common goal; To develop lab skills while solving a problem; To present information in written and verbal form.

How do we achieve these LARGE goals? Many small steps...

Standing Assignment

Each time you work on the project you (each individual person) must write in your own journal about the experiment. You should keep notes from research, data, ideas, lists of things to do... etc. Specifics will be provided for you.

STEP 1: Select your partner: (*Section Two*)

This may be one of the most important steps of the process. You will work with this person for the entire length of the project. Choose someone who will complement your talents. If you are excellent at writing papers but are terrified of speaking in public, choose someone who speaks well. If you love lab but have difficulty organizing the information into charts and graphs, then select someone with those skills. Also keep in mind your schedules, interests, and proximity of your homes.

School Activity: Partner Resumes and Interviews

Assignment 1: Partner resumes – collect resumes and interview your potential partners. You will each sign a contract stating your expectations of each other. Your teacher will witness your contracts and will hold you to these terms.

STEP 2: Select your topic: (*Section Four*)

This is second in importance in the project. Pick something in which you are interested or know a little. You will spend the entire year working on this topic. If you select a topic that is too broad then you will have difficulty conducting the research. If you select a topic that is too difficult you may not have the basic knowledge to develop an research project design. Your teacher will guide you but you must understand that if your teacher sends you in a different direction it is for your own good. Your topic must be something that you can do within our budget and time constraints.

Assignment 2: Make a list of 2 researchable topics in which you and your partner are interested. Your teacher will return this with suggestions and will then discuss them with you.

Assignment 3: In your lab book, write a problem statement and hypothesis based on the topic you selected.

STEP 3: Experimentation (*Sections Five and Six*)

This is the heart and soul of the project. You are the scientist! You are expected to design and conduct an experiment that is repeatable. You may not have time to repeat it, depending on the length of the project, but your procedure should be clear so that anyone wanting to repeat it could do so.

Assignment 4: In your lab book, develop the research project design following the directions given. Revise if asked to do so. Site the sources used in developing your design.

Assignment 5: Give your teacher a list of all materials needed to complete the experiment. If you miss the deadline for materials to be ordered, it will be your responsibility to acquire these materials on your own or choose a project so you can use materials available at home.

Assignment 6: Arrange a time to conduct the experiment. Conduct the experiment. Carefully record all data. All data must be well organized and recorded in your lab book.

STEP 4: Collection of resources for paper and presentation (*Section Seven*)

Literary sources should be acquired throughout the entire process. For this reason, notes and organization are important. Keep up with all sources so they may be cited in your paper. **Seven sources are required.** They must be properly documented using APA format and parenthetical documentation. Your sources must be of high quality. Two must be from peer reviewed journals and four must be from other high quality written sources. Only one textbook or encyclopedia may be used. Your teacher will provide you with a list of examples of high quality sources. Current newspaper articles will be acceptable and may provide a good source for application of your research. Sources from databases may be counted as written sources as long as they may also be found in print form. High quality sources will support your research and will help you write a strong paper.

Assignment 7: Turn in your literature cited page and notes from the sources.

STEP 5: Research Paper Introduction (*Section Seven*)

Even if you have not completed your experiment and collected all of your data you should have completed your literature search well enough to write the introduction section of your paper and be far enough into your

experiment to complete the materials and methods section of your paper. Scientific writing is very concise. Keep your paper short and to the point. Your paper should be double spaced, 12 pt. font and all sources should be noted in parenthetical notation. The *introduction* should include your hypothesis and any supporting information needed for the reader to become familiar with your topic. This should not be a list of definitions. Instead you should be asking and answering questions. Why is this a significant experiment? Is this experiment similar to a historically important experiment? What is known? What is still not known and what progress is being made in the field of study? Typically, this will be one of the longest sections of your paper and will use the majority of your sources.

Assignment 8: Turn in Introduction section of research paper. Additionally turn in Literature Cited page with sources cited in this section.

STEP 6: Research Paper Material and Methods (Section Seven)

The materials and methods sections should not include lists or give directions. It should be written in 3rd person past tense as is the rest of your paper. After all, you are reporting how the experiment was performed not how it should be conducted. You should reference any notes you have made in your research journal about the procedures and materials you *actually* used in conducting your experiment.

Assignment 9: Turn in Materials and Methods section. Additionally turn in Literature Cited page with sources used in these sections.

STEP 7: Analysis of data in journal and paper (Section Six)

Analysis of the data provides the information to support or refute your hypothesis. Data may be qualitative, that which involves observations of change, or quantitative, that which requires numerical data to be collected. Your instructor will help you determine which type of data you should collect. In either case, you should be able to draw conclusions about how your variable has caused a change.

Qualitative data: Experiments involving qualitative data will require a table which is organized so that information may be easily compared and conclusions may be drawn.

Quantitative data: These experiments must have at least one chart and one graph. Additionally, you must be able to give the equation of the line and relate it to the accuracy of your experiment if relating to a specific equation. The equation of the line may also evaluate the precision of the experiment, for example, how the data points stray from an indirect, direct or an exponential relationship. You should be able to discuss the trend of your data.

In addition to including a chart and a graph you must also write about the general trends that you observe in your data, any data that does not fit the trend, and reasons that might explain both of these. This section usually does not contain a large number of sources because it is your own data.

***Assignment 10:* Schedule a meeting with your teacher to discuss your data table and / or graph in your journal with your science teacher. Your teacher will help you determine the best way to analyze and summarize the data.**

***Assignment 11:* Turn in the Data and Analysis section of your paper to your teacher. This should be generated using a computer and printed.**

STEP 8: Research Paper Conclusion

This is the final section of the paper. You will draw from all of the other portions of your paper to write the conclusion without directly copying them. You will use your sources to help you support or refute your hypothesis. More importantly, you will draw conclusions about the data you have collected. These conclusions should not be duplicates of the statements made in your analysis section but should be more summative. Instead of saying, “the rate of change of variable A was 0.25 and variable B was 0.10”, you might say, “variable A had a greater rate of change indicating...” General statements of the data collected supported by other sources are the key to a good conclusion. Additionally, you should sight potential sources of error and suggest possible future experiments to further test your hypothesis or a new hypothesis. Finally, what is the significance of this experiment? How has this information been used in society or how will it be used? It might be helpful to ask yourself why did you conduct the experiment.

***Assignment 12:* Turn in the Conclusion with correct documentation and the Literature Cited page.**

STEP 9: Final Draft of the Written Research Paper:

One of the last steps of the scientific method is to report your findings. The general order of the paper will be: Introduction, Materials and Methods, Data and Analysis, and Conclusion. These headings should be included in the paper. All sources must be correctly documented in the text. Grammar and spelling do count. Your paper, not including the cover page or the literature cited page, should be approximately 5 pages. If you cover the topic well and it is more or less than 5 pages, do not worry. Just make sure you have earned all the points possible on the grading rubric given. There will not be a rough draft since each section of your paper has already been graded as an individual component. If you score poorly you

must make changes or your grade will decline even more. Additionally, the final draft must include an abstract and a table of contents. An abstract is a brief summary of the entire experiment. These few sentences should explain your entire experiment in a very concise way.

Assignment 13: Final draft of research paper with abstract.

STEP 10: Oral and Visual Presentation

This presentation will be given in front of your peers and will be graded using a rubric. You should use PowerPoint or the other presentation software to aid you in presenting your data. You might consider bringing an additional visual. This might be something used during your project or a demonstration that will be helpful in explaining your research project.

Assignment 14: Oral research presentation.

RESEARCH PROJECT TIMELINE

Organization and keeping track of progress can be a challenging part of research. Having multiple check points throughout the research process can facilitate better organization and in the end a better project. Below is an example of a potential research schedule. This schedule may be modified based on school start dates, external due dates or the level of the course.

Date	STUDENT TASK
Mid- August	Overview of project
Mid- August	Partners selected and contract signed Parent signature required
Late August	Project orientation in library and begin looking for topics
Early September	List of topics with source
Mid- September	Problem and Hypothesis due
Late September	1 st meeting research project design due and materials list of things needed to order. These are 2 different documents.
Early October	Library day to work on introduction section of paper and gathering of sources for paper
October and November	Students conduct research
Mid- October	Literature cited page for rough draft due
Late October	Library Time
Early November	Introduction and Literature Cited Page due
Mid- November	Materials and Methods due
November	Appointments to discuss data. Data must be in your journal.
Late November	Charts , graphs and analysis section of paper to science teachers
Early January	Library Day
	Conclusion due
Late January	Final Draft due – Must turn in rough draft, final draft, and rubric
Early February	Library day to work on presentations
Mid- February	All presentations due to teacher electronically
	Student presentations Provide printed slides for teacher
Late February / Early March	Submission of papers to competition

DEVELOPING RESEARCH IDEAS

Area of Interest:

These might be things you've study or read about in the past. You might also look at your book or in journals and magazines in the library.

Key words:

What are words that are associated with the topic? These will provide additional search options when looking for a topic and may provide ideas of potential experimental variables.

Potential questions:

After conducting a literary research, identify questions for potential projects. They may still be broad questions at this point but should be more focused than the initial topic.

Key Sources:

Locate a source that is related to one of the questions above. This does not have to be a source that details the experiment but instead provides a strong foundation for the development of the hypothesis

Experimental Description:

At this point all of the details do not need to be described but the variables should be identified and the method of measurement described.

Independent variable:

Dependent variable:

Method of measurement:

Can this be completed in 2-3 months with the materials available?

PROBLEM AND HYPOTHESIS WORKSHEET

Problem: _____

Independent Variable: _____

Dependent Variable: _____

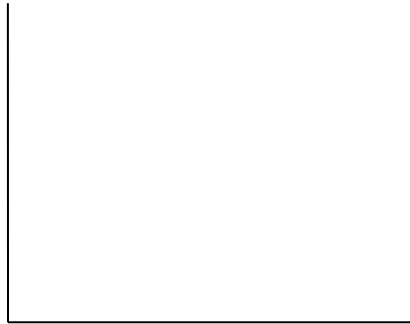
Explanation of effect of independent variable: _____

Prediction: If _____,

then _____.

Prediction graph:

Title: _____



Hypothesis: If _____,

then _____,

when _____.

DEVELOPING A RESEARCH PROJECT DESIGN

Please write this in the research journal.

Research design and planning is extremely important in science. When scientists plan how to conduct their experiment, they must do it in a manner that is clear, easily understood, and in a way that attempts to anticipate problems and needs in the experiment. The following is a description of the necessary parts of the research design.

*The **Problem and Hypothesis** are already in your research notebook, however, please restate them again. There may be some revisions you were asked to make.*

1. **Problem-** usually a single statement or a question.

The first step in any experiment is to ask a question or define the problem. This step is simply a statement of the problem. *Example:* Shade plants appear to do poorly in direct light.

2. **Hypothesis-** single statement.

The second step is to predict what the answer to the problem might be. This should be stated as an answer to the Problem, stating it in a manner that includes the question. It must be written in the “if, then” format with **1** testable variable.

1. **Materials-** list of equipment

The third step is to design an experiment to see if your hypothesis was correct. For this step, you will need materials. List all materials required to conduct your experiment. Keep in mind that this must be detailed.

2. **Method-** list of instructions.

The fourth step will be how you anticipate performing your experiment. This must be written as a list of instructions. The list should be numbered so that you may use these instructions as a guide while conducting your experiment. Although it is important to have a plan before you begin the experiment the plan may (and probably will) change once you get into the experiment. Often this is because of the type of equipment available, time limitations, unforeseen results, etc.

3. **Predicted Data-**

At this point you will not have any data but you should be able to make predictions. You should also develop a table similar to the type you will use to record your data be specific to the variables you will be observing, including units of measure. If your data is quantitative, you should be able to construct a graph of what you hypothesize your data will be in graph form. Your graph should include a title, both axes should be labeled with units but no numbers, and a line should be drawn. This line should reflect the type of data expected, for example you might indicate if you expect exponential results, positive, negative slope, etc.

LOOKING AHEAD: The following steps are not part of the research project design but should be considered as you are completing your experiment.

4. **Analysis-** what are the relationships between the variables?

The sixth step is to ANALYZE your data. This means that you are looking at the information you have gathered and you are trying to find patterns or meaning in it. This written portion has six steps. See checklist below:

- a. Restate your hypothesis
- b. Briefly tell what you did and what you used to do it.
- c. What was the pattern or trend that your data exhibited has shown you?
- d. Accept or reject your hypothesis
- e. Tell why you have either accepted or rejected your hypothesis. **THIS IS CRITICAL!** Explain how you decided to accept or reject your hypothesis **BASED ON THE DATA THAT YOU COLLECTED.**
- f. Tell about any error that could have affected your results.

7. **Conclusion-** a statement that wraps it all up.

The final step is to state what you have found in your research. The conclusion is a response to the original problem. A very important thing to consider is why is this research important? What is your purpose? Does this information impact the greater goals of an area of study?