How to Complete a Science Project

What is a Science project?
A science project is an independent study of a particular topic that uses the scientific method in order to answer a specific question about how or why something is being impacted in our world.

A science project is a science experiment. An experiment is a very specific type of science investigation. In an experiment, the researcher tests just one condition and sees what effect it will have on a test subject. The researcher can only make changes to that one, specific condition. Everything else in the experiment has to stay exactly the same for every trial, or else the experiment is not valid (fair).

1. Get an Idea for Your Science Project
Science is all around you. You use force and motion concepts when you ride your bike to school. You are impacted by the weather. Eating is a part of life processes. A science project is hiding inside everything that you do in your life. Start by asking “What if?” questions. For example, as you are riding your bike, think about what would happen if you had a bike with larger wheels, or smaller wheels. How would that change the speed you could go? That’s the start of a science project. Look around your world. Think about the things that you enjoy. Then start researching your favorite science topics to help you find a question that interests you. Talk over the list with your family, teacher or friends.

There are seven categories in the science division of the Science and Engineering Fair:

- ***Animal Sciences*** - This category addresses the study of all aspects of animals and animal life, animal life cycles, and animal interactions with one another or with their environment. This includes all aspects of human physiology, but excludes all human behavioral projects. It also includes the study of the behavior of animals. Many scientists work in the field of animal sciences. Some of them include:
    - physiology
    - mammalogy (mammals)
    - entomology (insects)
    - ichthyology (fish)
    - ornithology (birds)
    - herpetology (reptiles and amphibians)
- ***Chemistry*** - Studies exploring the science of the composition, structure, properties, and reactions of matter not involving biochemical systems are included in the Chemistry category. Chemistry careers include:
    - environmental chemistry
    - inorganic chemistry
    - organic chemistry
    - physical chemistry

- ***Earth and Environmental Sciences*** - This category focuses on Earth and the environment. It also includes meteorology and climate sciences. Possible fields in this category are:
    - atmospheric science and meteorology (weather)
    - climate science
    - environmental effects on ecosystem
    - geosciences
    - water science
- ***Human Behavioral Sciences*** - This category addresses studies of human thought processes, emotions, learning, decision-making, and behavior. Possible fields in this category are:
    - anthropology
    - psychology
    - neuroscience
- ***Microbiology*** - The microbiology category covers the study of microorganisms, including bacteria, fungi, prokaryotes, and simple eukaryotes, as well as antimicrobial substances. Microbiologists might study some of the following fields:
    - antimicrobial
    - bacteriology
    - environmental microbiology
    - microbial genetics
- ***Physics and Astronomy*** - Physics is the science of matter and ***energy*** and of the interactions between the two. Astronomy is the study of anything in the universe beyond the Earth. This category would also include studies of renewable energy structures (wind or hydroelectric turbine, photovoltaic cell, etc.) and/or processes, including energy production and efficiency. In this category, some possible career fields are:
    - electrician
    - astronomy, cosmology, and astrophysics
    - biological physics
    - magnetics and electromagnetics
    - mechanics
    - optics, lasers
- ***Plant Sciences*** - This category includes any project dealing with plants and how they live. If plants interest you, these are some of the careers you might choose:
    - agriculture/aquaculture
    - ecology
    - genetics/breeding
    - physiology

2. Start a Scientist's Log Book

A detailed scientist's log book with accurate records allows scientists to describe their investigations so others can repeat it and try to replicate the results. A bound notebook (such as a "composition notebook") is the best for a log book because it is a "legal document". A scientist's log book can be used to show timelines and dates. This could help the scientist prove that the results are not copies from someone else. For this reason, the book should be written in ink and mistakes should not be erased. Don’t worry about mistakes. Just put one line through it so they can still be read. This information could possibly be used at another time.

Setting Up Your Scientist’s Log Book: Divide the log book into two sections:

- In the **Daily Work** section, write down all the things you do or think about concerning your project each day. ***Make sure you date every entry.*** Think of it as a daily blog post:
    - What did you do today for your project?
    - Did you discuss the project with anyone?
    - Did you consider how to gather materials?
    - What issues did you run into today?
    - What did you research? Make sure to add the bibliography information for each source as you come to it.
    - Give details! Each day’s entry should show the progress on your project.

- In the **Data** section, make charts **<u>before</u>** you start testing. The data section of your log book should have all the data and observations from your testing. If you make a mistake, draw a line through it and rewrite it. Do not erase or white out a mistake.
    - Record all **measurements** in ink as you measure them during your testing.
    - Make **observations** during your testing. Observations help the scientist explain the data. For example, in one trial there may be a significant difference in the measurement from another trial. Through close observation, a scientist may notice something, such as wind changing direction, during a trial. These careful observations can help in explaining differences in trials.

3. Complete the <u>Project Approval Form</u> - 2 pages

This form lets your teacher know what you’ve chosen for your project. It gives an overview of your project with enough detail that anyone who reads it can get a pretty good idea of what you will be doing. Once your teacher approves the project, he/she will give this form back to you. It will have a list of other forms you will need to complete before you begin your project. ***Make sure you keep this signed form and all forms you complete--they are required to be turned in with your project.***

4. Become an Expert on Your Problem

The research phase of your project is very important. This is where you learn everything you can about the topic of your project. Spend some time getting background information. Good research will help you become an expert on your topic. Remember to write down the bibliographic information about each source you read, consult, or try to contact. Some ideas for places to go for research are:

- library
- internet--Make sure it is a ***reliable*** source of information (talk to your school media specialist about this).
- experts in the field
- Write to companies involved in your field.

5. Complete <u>Ethics Agreement</u> and <u>Risk Analysis and Designated Supervisor Form</u>

By signing the *Ethics Agreement*, you are saying that you won't copy someone else's work. You can refer to someone else's work, but you have to cite it in your log book and on the bibliography. Copy-and-pasting images, words, etc., from the Internet is considered plagiarism. If you identify *where* you got each part of what you copied (cite the source), you have done your job.

The *Risk Analysis and Designated Supervisor Form* is used to state all the risks in your project. Risks might include:

- the tools and materials you are using. How can you stay safe when you use them?
- the location you are testing in. Is it close to a road or body of water?
- the science safety tools you will be using.

In this handbook, the <u>Risk Assessment and Safety Considerations</u> section will help you complete this form.

6. Identify Your Variables

In an experiment, scientists call the conditions in their experiment "variables." It is very important to identify and control variables.

There are 3 types of variables:

- **independent variable** - This is the one thing you are changing in your experiment.
- **dependent variable** - This is what changes as a result of changing the independent variable. This is what you will measure to collect data.
- **controlled variables** - This is ***everything*** else in the experiment. These must be kept exactly the same in all your trials, or else it's not fair.

In your experiment, what are you changing? For example, if you are doing an experiment about whether adults or students are better at shooting basketballs, the thing that you are changing is the age of the test subjects (adults or students). That's your ***independent variable***.

How are you going to measure your experiment? In the example above, you'd measure it by counting how many shots each person made successfully. That's your ***dependent variable.*** The dependent variable is the data you will record for your experiment.

The final variable is the ***controlled variables.*** This is everything else in your project. Go back to the basketball example. Would it be fair to let the adults shoot from right under the basket, but the students have to shoot from the half-court line? NO! The controlled variables keep the experiment fair.

7. State the Problem in a Question Form

The Question asks what you are trying to find out or solve by testing. Make sure your question is a testable question. It should not be a demonstration, survey, or collection. Two common formats used for writing a question are:

How will salt affect the boiling temperature of liquids?
What are the effects of salt on the boiling temperature of liquids?

Be careful when using the words "affect" and "effect" because they are often confused and misused.

- "Affect" is a verb that means "to influence". In the example above, the student is asking if salt will "influence" or affect the boiling of water.
- "Effect" is usually used as a noun that means "a result, or something brought about by a cause." In the second example above, the student is asking what the "results" or "effects" will be when they add salt to boiling liquids.
- "Effective" is an adjective meaning "producing an expected result." It is also sometimes misused. A correct example would be, "Which of the tested air filtering systems is most effective?"

Some other formats that can be used are:

- "What happens to the stability of a boat when the pontoon design is changed?"
- "Is there a relationship between light color and the growth of bean plants?"
- "Which of the tested materials provides the best insulation?"

Your variables can help you write your Question. In the examples above, see if you can identify the independent variable (what the researcher is changing) and the dependent variable (what the researcher is measuring). Here are a few:

- How will salt ***(independent variable)*** affect the boiling temperature ***(dependent variable)*** of liquids?
- Is there a relationship between light color ***(independent variable)*** and the growth ***(dependent variable)*** of bean plants?

8. Identify Your Control Group and Experimental Group

It is very important to have a ***Control Group***. This is the group that is treated in the "normal" way so you can compare them to the ***Experimental Group***. The Experimental Group is the one that gets the ***independent variable***. Let's look at an example:

> How will salt affect the boiling temperature of liquids?

Salt is the independent variable, so the ***Experimental Group*** is the group that gets the salt added to the liquid. The group without the salt is the "normal" group--the ***Control Group.***

If your Question is based on a "What if…" question, you <u>do</u> have a Control Group--the situation that made you start wondering. If you were pitching a softball and started wondering, "What if it was raining and the softball was wet?" Your Control Group would be testing with dry softballs and your Experimental Group would be testing with wet softballs.

9. Research

Scientists need to get a full picture of the problem they are addressing before they start testing. That is where research comes in. You may want to start by researching to find out what other scientists have found about your topic in the past. Research will help you to fully understand your topic and help you to come up with a way to design your experiment.

For the Science and Engineering Fair, at least ***3 sources*** are required for the research phase. These sources must be documented in both the log book and on a bibliography. Interviewing an expert in the field of your project is an acceptable source. ***If your project uses a non-human vertebrate, one of your research sources must be about how to care for the animal.***

10. State Your Hypothesis

The hypothesis is a prediction of what you think will happen during your experimentation. Use background information to help you prepare the prediction. Be sure to write your hypothesis before you start your experiment. Write it as an "If…, then…" statement.

> In the example about the basketball experiment, a hypothesis might be, "**<u>If</u>** adults and students shoot 50 free-throws each, **<u>then</u>** the students will shoot an average of 5 baskets more than the adults.

A note about the Hypothesis: The results of the tests you will do later do not have to support the hypothesis in order for the experiment to be a success. It is important to note that your hypothesis will NOT be "proved" or "disproved." Hypotheses are either "supported by the data" or "not supported by the data." They aren't proved; they aren't right; they aren't wrong.

11. Design the Experiment and Write a Procedure

The Procedure is the method you will use to test your hypothesis. The Procedure should explain the steps to be followed in order to find the answer to your question or problem. This is where you write how you will control all the variables. It is also where you write how you are going to control the risks you identified in your *Risk Assessment*.

It is very important that your Procedure is very specific and detailed, like a recipe in a cookbook. Other scientists should be able to pick up your Procedure, conduct your experiment and get very similar results. This is called a "replicable experiment." Replicable means repeatable. All scientists work very hard to have a replicable experiment--if it's not replicable, it's not considered valid. One way to check if you've added enough detail is to have someone else take your Procedure and try to walk through the experiment (without actually using the materials). As that person tries to follow your Procedure, watch for steps you forgot to write.

Repeated trials should be part of your Procedure. Be sure to follow this very important part of the scientific method. In order for results to be considered valid, the experiment must be conducted multiple times and yield consistent results. There **must be** at least 3 trials, but 5-10 trials are preferred. The results will be more valid if you repeat the experiment as many times as possible.

After you've written your Procedure, go step by step and pull out the materials you will need to gather for your project. Be very specific about the amount of each material you will need.

Make sure that both the Procedure and Materials are written in your log book.

12. Conduct the Experiment
Follow your Procedure carefully to ensure valid scientific testing. While testing, record all data, in ink, directly into your log book. Be accurate and exact as you observe, measure, describe, count, and/or photograph. If necessary, make changes in your Procedure and document them in your log book. However, if you do make changes, you have to start your testing again. It wouldn't be valid to do half of the tests with one Procedure and the rest of the test with a different Procedure.

It's important to also write your observations during your testing. Your observations can help you make sense out of your data. Did you have one trial that had a different result from the others? What did you observe during that trial?

3. Analyze the Data (Results)
Look closely at the measurements you recorded in your log book. Think about the data and decide what the results mean. Try to find explanations for your observations. If possible, examine your results mathematically using percentages, mean, median, range, and mode. Be sure to know the meanings of these words if you use them. Also, in your results, identify data that is unusual or unexpected and try to explain it in your conclusion.

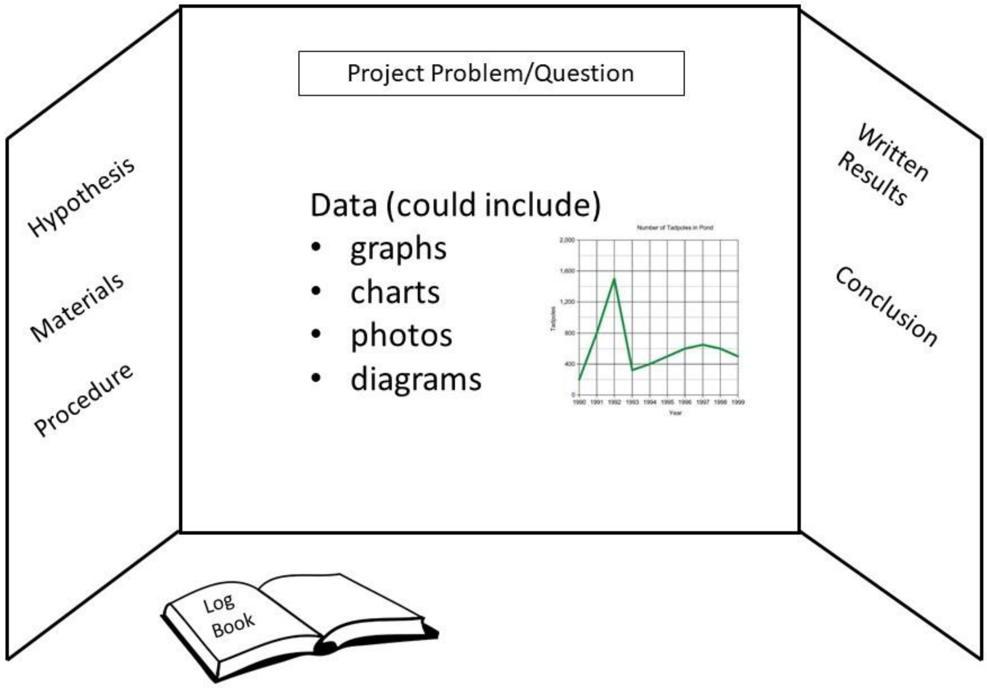
Graphs are used to make the data, trends, and patterns easy to understand, but you have to select the correct kind of graph. If you use a computer program to make your graph, you have lots of options. However, not every graph is appropriate for every project. The graph you choose should be easy to understand--just because it looks really interesting doesn't mean it's the best graph. The charts or graph will also go in your log book and on your display board. Make sure you include a key to help others read your graph.

14. Make Conclusions
Conclusions are statements telling what you found out or learned during your investigation. This is a very important part of your project since you have likely learned a great deal. The conclusion is based on the results of your experiment. You will explain how the data you collected either does or does not support your hypothesis. Explain what further testing might be done to further answer your original question. Tell how people might apply your findings to everyday life. If you were to repeat this project, what changes would you make?

15. Communicate Your Results/Construct a Display

An important part of the scientific process is to share results with others. It is good to let others know what you have learned. You should be able to fully explain all parts of your project. The Sample Interview Questions section of this handbook can help you prepare to share your project with others.

This is a sample of a science project display board. Your board does not have to match this exactly, but it MUST have your problem and tell the story of your project.



SEF Student Checklist

Science Division

Student Name____

check each box	Congratulations on completing your project! Use your SEF Student Handbook and this checklist to be sure you have completed all of the required parts and that you stayed within the rules for your project. ***In order to be safe and fair, if you don't follow the rules, your project will not be permitted in the Regional Science and Engineering Fair.***
☐	Check the box if you have completed and signed all of the ***necessary forms*** for your project. Look on page 2 of your Project Approval Form for what you need.
☐	Check the box if your ***testable Question*** is on the board or in your log.
☐	Check the box if your ***Hypothesis*** is on the board or in your log.
☐	Check the box if your ***Materials*** list is on the board or in your log.
☐	Check the box if your ***Procedure*** is on the board or in your log.
☐	Check the box if your ***Results/Data*** are on the board ***and*** in your log.
☐	Check the box if your ***Bibliography*** is complete, with at least ***three sources,*** and with your project. ● If your project uses a non-human vertebrate, one of the sources ***must*** be about how to care for the animal.
☐	Repeated trials are important for a valid experiment. Check the box if you did ***at least*** 3 trials. ***Any project with less than 3 trials will not be entered in the Regional Science and Engineering Fair.*** The more trials you do, the more valid your results.
☐	A ***log book*** is required for each student scientist (team projects require a log book for each student). Check the box if ***your log book is complete and with your project***.
☐	You can use ***photographs,*** (even ones that show your face), but you have to tell who took the photos. If the same person took them all, just put one label that says, "All photos taken by _______." But only use first names. You can also say, "Scientist's mom took this photo," or "Photo taken by scientist." Check the box if you have labeled your photographs.
☐	Items used from the ***Internet*** (articles, graphs, charts, pictures, etc.) need to have labels to cite the source. For example, "This chart was from (URL of website)." Check the box if you've labeled your Internet sources (if this applies to you).
☐	Check the box if your display board is able to ***fold and lay flat*** and does not contain prohibited objects (such as lighting, soil, rocks, liquids, living or dead organisms, blood, sharp objects, plastic bottles, etc.).
☐	Check the box if your project ***meets all of the rules and requirements*** outlined in the *SEF Student Handbook*.

Judging Criteria: *Science Division*

_________________________/____

Project Number *Category*

Project Problem ____

	Superior	Very Good	Good	Poor	Notes
Research Question • clear and focused • testable using scientific methods • real-world application	10	8	4	2	
Design and Methodology • well-designed plan (easily replicated) • variables identified and controlled	15	10	5	2	
Data Collection/Analysis • systematic data collection • sufficient repeated trials to ensure data validity • conclusion supported by data	15	10	5	2	
Representation of Data • accurate application of mathematics for analysis • clarity of graphs/charts • appropriate representation of graphs/charts	10	8	4	2	
Log Book • detailed observations/entries • sketches/diagrams • dated entries • evidence of research • bibliography (at least 3 sources)	15	10	5	2	
Interview • clear, concise, thoughtful response to questions • understanding of science concepts • degree of independence • lessons learned • ideas for future research • If team, both members demonstrated significant contribution to project	15	10	5	2	
Display • logical organization of project content • tells story of project • shows student learning	10	8	4	2	
Creativity • project demonstrates imagination and inventiveness • project opens up new possibilities or new alternatives	10	8	4	2	

**Form to be printed in green for the Regional Science and Engineering Fair.

Total ____________