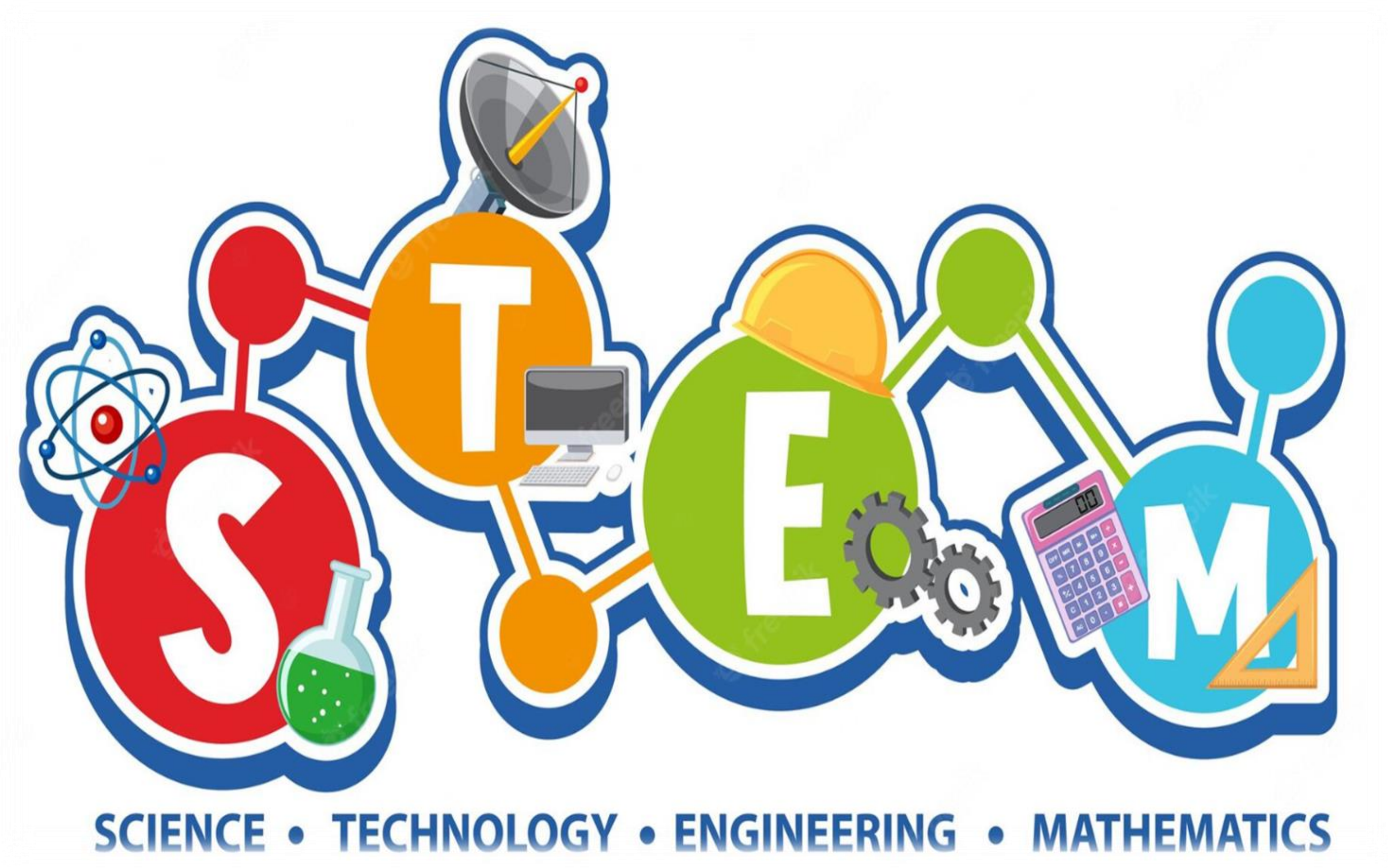
Elementary Science and Engineering

Student Support Guide

September 2022



What makes a good science or engineering project?

- ✓ You're interested in the topic—it's something that you like to think about.
- ✓ You can conduct an investigation to answer the question or create a product to solve a problem.
- ✓ You have a variable that can be observed and measured using qualitative or quantitative data.
- ✓ You can do it with a little help from parents, teachers, and friends.
- ✓ It doesn't harm, hurt, or scare people or animals
- ✓ You learn and it makes you think of "I WONDER" questions, even when the project is completed.

How to choose a topic and create a question to investigate?

A great science project ALWAYS starts with a "**TESTABLE QUESTION.**" A great engineering project ALWAYS starts with trying to find a **"SOLUTION TO A PROBLEM."**

- Students should make a list of 5 high interest topics.
- Using the list, students should write an **"I WONDER"** question related to each topic that they might want to explore.

Remember, not all topics can be explored through an investigation. For example, it might be very interesting to learn about Mars, but it would be very difficult to create a question about Mars that could be investigated with an experiment.

Planning a Scientific Investigation

The **Scientific Method** is used as a guide to conduct a fair test or investigation. The Scientific Method can be found in many formats, but here are the important steps:

- Be sure the question is **"TESTABLE."** The question should be something that can be tested by measuring a change in a variable.
- **RESEARCH** to discover what scientists and engineers already know about the question. Be sure to use a variety of books and internet sources. Be sure that online sources are good quality sources and have students record notes.
- State a **HYPOTHESIS.** State what you think the outcome of the investigation will be, using an "if, then" statement. For example, "If pumpkin seeds are planted in clay, sand, and potting soil, then the pumpkin seeds will grow taller in potting soil.

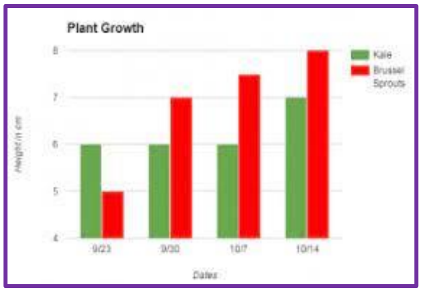
- Identify **VARIABLES,** the factors that can change or be changed in an experiment.
  - The **<u>independent (manipulated) variable</u>** is the variable changed by the investigator.
  - The **<u>dependent (responding) variable</u>** is the variable that is measured, counted, or observed by the investigator.
  - **<u>Controlled variables</u>** are those conditions that are kept the same.

For example, in the pumpkin seed experiment, the different types of soil used by the scientist would be the independent variable. The dependent variable would be the height in centimeters that the plants grew. For all plants, the scientist would be sure to plant pumpkin seeds in the same sized containers, use the same amount of soil in each container, water each container with the same amount of water, and be sure each plant received the same amount of sunlight. These are controlled variables.

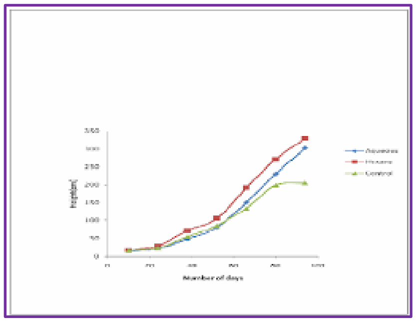
- **MATERIALS LIST** make a detailed list of the appropriate tools, instruments, and materials needed to conduct the investigation.
- Write detailed **PROCEDURES.** Someone should be able to follow these “directions” and repeat the experiment exactly how the scientist completed it.
    - The procedures should indicate how the variable is being manipulated, how to measure the response, and when and how the data will be recorded.
    - Record data using metric units.
    - The procedure should include at least 3 trials.
- Carrying out the **INVESTIGATION and COLLECTING DATA**. Be sure to follow the written procedure.
    - Use a **log book** to take detailed notes. A log book is a dated record of all work done on the science project. Include detailed notes, labeled drawings, pictures, and qualitative and quantitative data.
    - **ORGANIZE DATA** in a table. An example is pictured below.

Day	Height (cm)		
	Clay	Sand	Potting Soil
1	0cm	0cm	0cm
5	1cm	.5cm	2cm
10	2 cm	2cm	4cm
15	4cm	2cm	6cm

- **ANALYZE DATA**. Look for patterns and trends. Calculating the average (mean) may be helpful.
    - Choose a bar or line graph to represent your data.
        - Place the independent variable on the horizontal (X) axis.
        - Place the dependent variable on the vertical (Y) axis.
        - A **bar graph** is a good choice when counting or comparing two or more groups.



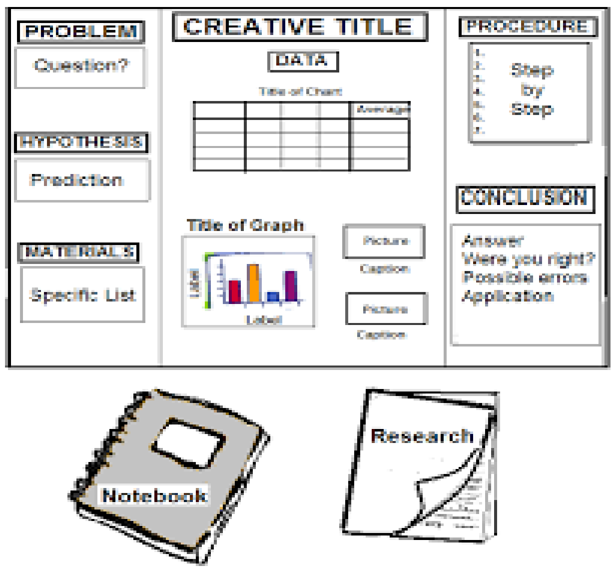
        - A **line graph** is a good choice when showing change over time



- **CONCLUSION** is a paragraph that begins with a statement describing if the data supported or did not support the hypothesis. It should include the following:
    - Summary of results including any averages, patterns, or trends. Did anything stand out about the results?
    - Is there anything that would be done differently?
    - What was learned from the project?
    - How would you like to continue research on this topic or question?
    - Make real-world connections or applications.

Creating a Display

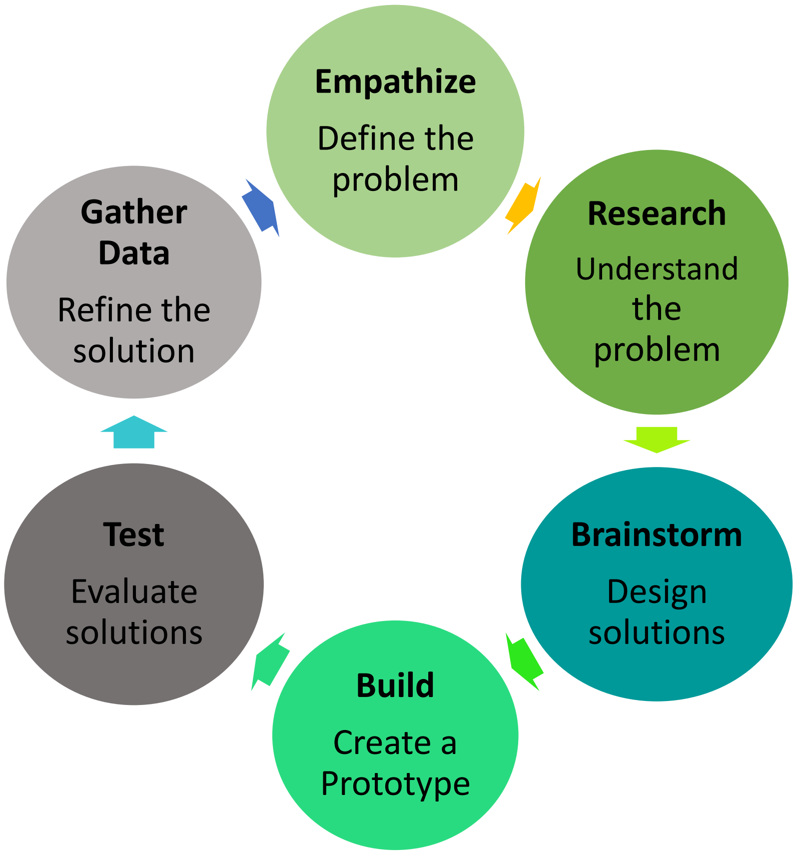
Use the example below to organize the display board.



- Communicating results is important! Use your log book to sketch out a plan for your display board.
    - If possible, use a computer to type and print information. Otherwise, use your best handwriting, and be sure it is large enough to be easily read.
    - Use glue sticks to mount your paper to the display.
    - Be sure all photos and drawings are done by you.
    - No photos of yourself should be displayed on the project board.
    - Your name should be written on the back of the display board.
    - Be CREATIVE!

Planning an Engineering Investigation

The **Engineering and Design Process** is used as a guide to solving a problem by creating a product, program, experience, or environment. This process emphasizes open-ended problem solving and encourages students to learn from failures, just as engineers in the real world. The Engineering and Design Process can be found in many formats, but here are the important steps.



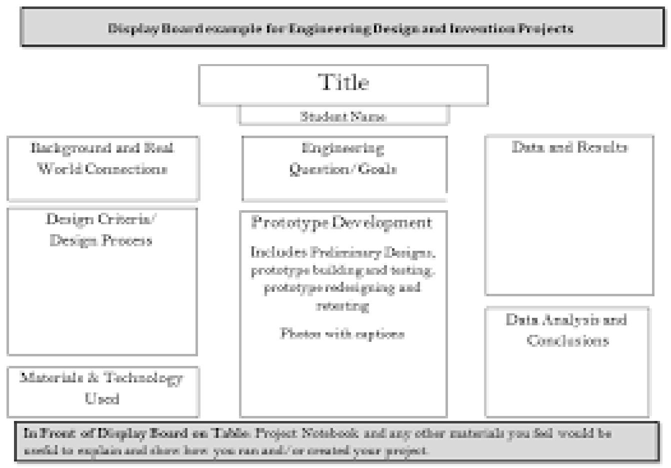
- Ask **QUESTIONS or DEFINE THE PROBLEM.** Engineers ask critical questions or identify a problem. What is the problem? What do we want to create? What do we want to design? What do we want to accomplish?
- **RESEARCH THE PROBLEM.** Research what products and solutions already exist or what technologies might be adaptable to your needs.
- **IMAGINE/BRAINSTORM** possible solutions. Brainstorm ideas and develop as many solutions as possible.
- **BUILD** a prototype of your design solution.
- **TEST AND EVALUATE PROTOTYPE** to determine if it solves the problem. Record your results.
- **IMPROVE-REDESIGN AS NEEDED.** Improve your solution if needed. Make revisions, draw new designs, rebuild prototypes, test, and re-evaluate.

Engineering Design Process Notebook

The **Engineering Design Process Notebook** will be used to document the process and will include the following components:

- **Identify the needs and constraints**
- **Research the Problem**
- **Brainstorm/Create a List of Possible Solutions**
- **Plan a solution**
- **Create**
- **Evaluate the Prototype**
- **Improve the Design as Needed**

Engineering Design Display Board



Judging Information

A science fair is an exhibition of student work, but it is also a friendly competition. Your projects will be judged on the criteria listed below.

- Scientific Thought
  - Is the problem or question clearly stated?
  - Is there a procedural plan for obtaining the solution?
  - Are the variables clearly recognized and defined?
  - Is there adequate data to support the conclusions?
  - Does the scientist understand the project's connection to related research?
- Engineering Goals
  - Does the project have a clear objective?
  - Is the solution workable?
  - Could the solution be utilized in a successful design or construction of an end product?
  - Is the solution a significant improvement over previous alternatives?
  - Has the solution been tested for performance?
- Creative Ability
  - Does the project show creative ability and originality in the questions asked?
- Thoroughness
  - Was the purpose carried out to completion?
  - How complete are the project notes?
  - How much time did the scientist(s) spend on the project?

Project Rubric

Criteria	Rating Scale				
Scientific Thought/Engineering Goals/Question Is the problem/question stated clearly or does the project have a clear question that is well written and testable?	**1**	**2**	**3**	**4**	**5**
Materials Are all materials listed with the amounts and metric units where applicable?	**1**	**2**	**3**	**4**	**5**
Test Design Is the plan to validate or confirm the hypothesis provided?	**1**	**2**	**3**	**4**	**5**
Variables and Controls Are variables identified correctly and labeled as independent/manipulated or dependent/responding?	**1**	**2**	**3**	**4**	**5**
Data Collection Are graphs used correctly (labels, titles, etc.,) and appropriately interpreted?	**1**	**2**	**3**	**4**	**5**
Results/Conclusions Are the results thoughtful, and were conclusions identified based on data?	**1**	**2**	**3**	**4**	**5**
Visual Display Does the project have quality construction (visuals, organization, spelling, grammar, and clarity of ideas)?	**1**	**2**	**3**	**4**	**5**
Repeated Trials Were at least 3 trials used and an average taken for the final data set (when collecting quantitative data)?	**1**	**2**	**3**	**4**	**5**
Creative Ability Does the project show creative ability & originality?	**1**	**2**	**3**	**4**	**5**
Thoroughness Does the project carry out its purpose to completion?	**1**	**2**	**3**	**4**	**5**
Scientist Interview Is the scientist able to explain the objective/purpose of the project? Can the scientist explain the process of completing the project and what was learned? Can the scientist explain how the project can be pursued in greater depth?	**5**		**15**		**25**
Total Score: _____/ 75					

Scientific Investigation

Graphic Organizer

Make a list of 5 topics that you find interesting.	Write a question or problem statement from each topic that you might want to explore.
Example: Gardening	*Example: How does the type of soil affect plant growth?*
1.	
2.	
3.	
4.	
5.	

Thinking about Science Investigations

Research

What do scientists already know about your topic?

Books	Websites

Research Notes:

Formulating a Hypothesis

Example: **If** pumpkin seeds are planted in clay, sand and potting soil, **then** the pumpkin seeds will grow taller in potting soil.

If____,

then____,

____.

Identify Variables

Independent *(manipulated)*	**Dependent** *(responding)*	**Controlled**

Tools/Instrument and Materials List

Quantity	Tool/Instrument/Material

Procedures

Step 1:
Step 2:
Step 3:
Step 4:
Step 5:
Step 6:
Step 7:
Step 8:
Step 9:
Step 10:

***Your project may have fewer or more steps.**

Now it's time to **carry out your investigation!**

- Use your log book to take detailed notes. Your log book is a dated record of all work done on the science project. Include notes, labeled drawings, pictures, and qualitative and quantitative data.
- You will organize and analyze your data, write a conclusion, and sketch out your display board in your log book.

Engineering Design

Define the Problem

Graphic Organizer

Make a list of 5 problems you would like to solve	Write a question or problem statement from each topic that you might want to explore.	What do you want to accomplish?
Ex. The roof of my doghouse leaks when it rains.	*Example: How can I design a waterproof roof to keep my dog dry?*	*I want my dog to stay dry while in the dog house.*
1.		
2.		
3.		
4.		
5.		

Research

What do engineers already know about your topic?

Books	Websites

Research Notes:

Brainstorm

Develop a Possible Device/Solution

Clearly explain how your device/solution will solve the problem.

Sketch Design

Build a Prototype

This design solution will help you determine if the design solves the problem. Push yourself for creativity, imagination, and excellence in design.

Test and Evaluate Your Prototype

- ✓ Does it work?
- ✓ Does it solve the problem?
- ✓ Communicate the results and get feedback.
- ✓ Analyze and talk about what works, what doesn't, and what could be improved.

What works?	**What doesn't work?**	**What could be improved?**

Redesign as Needed!

Sketch new designs.

Now it's time to **carry out your investigation!**

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Tri-Fold Board Components

Scientific Method Process

Title
Purpose
Testable Question
Hypothesis
Materials
Procedures
Variables
Data
Repeated Trials
Results/Conclusion
Abstract (4th and 5th Grade)

Purpose	Title	Data Table
Question		
	Procedure	Graph
Hypothesis		
		Conclusion
	Variables	
Materials		
		Abstract*

Engineering Design Process

Title
Problem
Background/Real world Connection
Prototype Development
Design Process
Materials/Technology Used
Data
Results/Conclusion
Abstract (4th and 5th Grade)

Background/Real World Connection	Title	Data Table
	Problem	Graph
Design Process		
		Conclusion
	Prototype Development	
Materials		
		Abstract*