Workshop #2 - Using the Scientific Method/Engineering Design Process: Writing a Problem Statement/Goal to Organizing Data

Presented by the GSDSEF Student Leadership Board
October 8, 2022

SLB Members Introduction

(Kavya, Eleanor, Maanas, Will, Arnav, Ronald, Vidhi)

AGENDA

During the presentation, if you have a question on the topic or need clarification, unmute your audio.
After the presentation, a copy of the slideshow and video of today's presentation will be available on the gsdsef.org website–SLB

- ❏ Overview of the **Scientific Method** and **Engineering Design Process**
- ❏ Components of the **Scientific Method**:
  - ❏ How to write each component
  - ❏ Examples of each component
- ❏ Components of the **Engineering Design Process**
  - ❏ What each component is and looks like
  - ❏ Examples of each component
- ❏ Collecting and organizing data and/or test results

Science Project VS Engineering and Computer Science Projects

Which type of project do you have?

SCIENCE = INQUIRY

Are you trying to understand something, gain knowledge or add to a body of knowledge?

Are you creating your own experiment to test a hypothesis?

Are you asking "What would happen if…"

Are you asking "Why does this happen?"

↓

Scientific Method

ENGINEERING/COMPUTER SCIENCE = DESIGN

Are you try to find a solution to a problem?

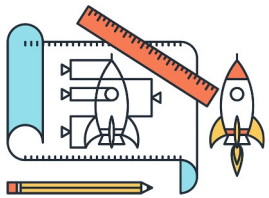
Are you trying to design, build, create or improve a product or process?

Are you creating models or a computer program?

Are you asking "Can I build/create a better process, application, or product for…?

↓

Engineering Design Process



Science Project VS Engineering and Computer Science Projects
Which type of project do you have?
Which category do you choose?

Many projects overlap between Science and Engineering.

Mathematics and technology/computer science are used in most projects.

A project can be interdisciplinary and fit in multiple categories.

Read the GSDSEF categories carefully.

Choose the category that best reflects the subject you are studying rather than the methods you are using.

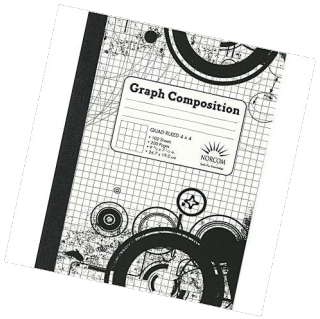
Keeping a Notebook for Raw Data

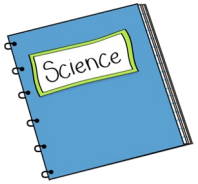
RAW DATA NOTEBOOK–to record initial data

Purpose: To keep a detailed and permanent account of the progress of your project

Contains items such as:

- Notes on background research
- Materials List
- Set-up of Experiment/Procedures
- Interviews with users or experts
- Observations
- Drawings and sketches
- Lists of design requirements
- Data collection in real time
- Questions/issues you face
- Background research sources





BEST PRACTICES

- Use a bound notebook (lined or quad-ruled)
- Use ink
- Create an ongoing table of contents
- Number the pages
- Date the pages
- Glue or tape down pictures, drawings, sketches, etc.
- Date and Identify Trials Data/Prototypes

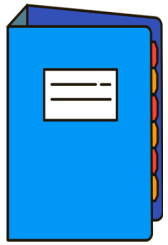
Keeping a Notebook for Final Presentation

FINAL REPORT NOTEBOOK-Required by the GSDSEF

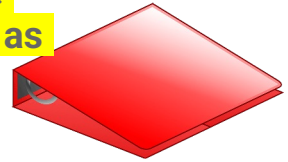
Purpose: To present your final findings and for submission to the GSDSEF

Contains:

- **Each step of the scientific method or engineering design process of your project.**



- **Organized, neat, detailed, complete information of your project, as well as sources, resources**



Best Practices:

- Type each section using an easy to read font
- All tables, graphs, etc. are clearly labeled and generated using a software program
- Ensure all pages are secure in a binder of appropriate size, or 3-pronged folder so pages cannot be removed.
- Edit for spelling, grammar, capitalization, and sentence structure!

Sample Science Notebook can be found: gsdsef.org.-->Students→ Resources

https://www.gsdsef.org/students/resources
Section-D > Sample notebook

Example: The Effect of Pre-treament of Raphanus sativus Seeds On Percent Germination and Growth Rate

Insert image if desired

Science and Engineering Projects

Page 2 of the student notebook

Background Research

- Contains:
  - 2-5 typed pages
  - Your research!
    - What is the problem and its history?
    - Why is it important?
    - What have others done to test/address it?
    - Why is your method the best way to investigate it?

Give credit where credit is due! Cite your sources in the bibliography. (minimum of 5 for junior division, 10 for senior division)

Science Projects

Page 3 of the student notebook

Statement of Problem - Definition

What are you investigating?

- This clearly defines your project and must be testable.
- It summarizes the problem you are investigating.
- It is usually written as a question or simple statement:
  - What is the effect of ___ on ___?
  - The effect of ___ on ___.
  - How does ___ (verb:make/affect/change, etc.) ___?
  - To what extent does ___ have on ___?

(Note: The title of your project is based on your problem statement)

Science Projects

Page 3 of the student notebook

Statement of Problem – Examples

Examples:

- How does the concentration of aloe vera juice affect the regeneration time in planaria?
- How does temperature affect the ascorbic acid concentration levels in orange juice?
- To what extent does the amount of humidity affect the growth of fungi?
- Which arch curvature shape allows for most load bearing strength?
- The effect of seed pre-treatment on the germination and growth of radish seeds when soaked for different amounts of time.

Science Projects

Hypothesis - Definition

Page 4 of the student notebook

It is a proposed explanation or prediction

- **Based on**
  - your research
  - the problem you identified
- **Must be**
  - testable **&** replicable
- **Contains the**
  - independent variable
  - dependent variable

It can be written as an **If** {these changes are made to a certain *independent variable*}, **then** we will observe { change in a specific *dependent variable*} statement.

Hypothesis - Examples

Examples:

- A higher concentration of aloe vera juice will decrease the regeneration time in planaria. (**If** higher concentration of aloe vera juice is given to planaria, **then** their regeneration time is decreased.
- Radish seeds watered with higher concentrations of acidic water and higher concentrations of alkaline water will result in decreased germination as compared to lower concentrations and neutral water.
- **If** temperatures are raised in orange juice, **then** ascorbic acid concentration levels will decrease.

Materials

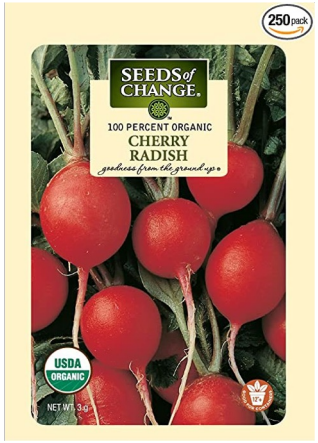
- **Be very specific with materials**
- **Include measurements/amounts/size of materials with the item**
  - **Use metric system!!!**
- **Make list in bulleted format (see example below)**

Example:

- **500 ml reverse osmosis water**
- **2 AA alkaline batteries**
- **25 cm x 10 cm x 1.5 cm pine plywood**
- **2 packets of (name of company) radish seeds**
- **Digital scale set to grams**

Materials- continued

- 2.5 Kg of Miracle Gro Soil
- 2.5 Kg of Gro Rite Soil
- 2.5 Kg of Garden Soil
- 3 100 mL graduated cylinders
- 90 150 mL plastic cups
- Tap water
- 90 Radish Seeds

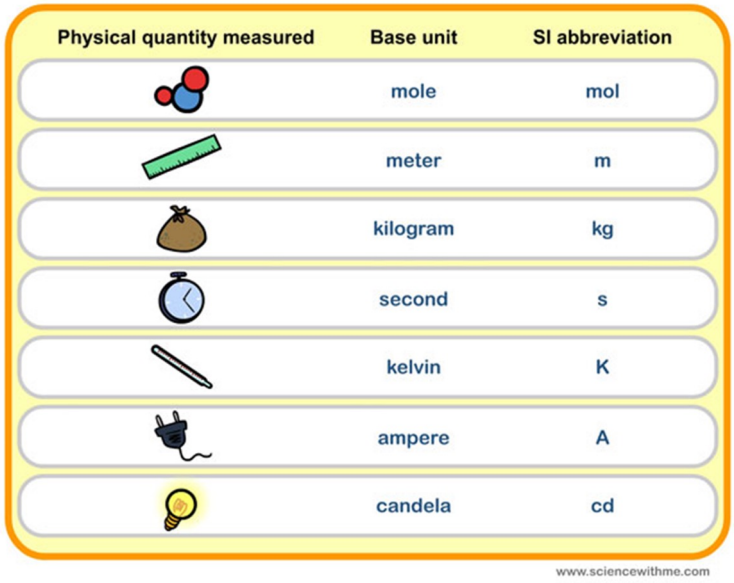


Science Projects

Page 6 of the student notebook

Designing an Experimental Procedure

- List the steps to perform your experiment in sequence.
- It must be detailed enough for someone to repeat your experiment exactly as you did
- Document your procedure with pictures of important parts of the procedure.
- Use only Metric Units! No feet, inches gallons, etc.



Procedure – Continued

- Make sure you have done enough trials and have collected enough data for each trial to be able to analyze the results and draw a conclusion.
- Number of trials may depend on the type of project, but generally 3 to 8 trials are adequate and each trial should have at least 10 to 30 data points or measurements.
  - If you are working with plants, you need to have at least 30 plants per experimental group and at least 30 plants in the control group.
  - If you are working with human subjects, have at least 50 volunteers.

Procedure- Example

1. 150 Brown Planaria were ordered from Carolina Biological to ensure 108 viable, healthy worms.

2. The Planaria were placed in an aerated, shallow aquarium with Spring Water and fed 2g of beef liver for a week before the experiment.

3. Three Aloe Vera plants of the same species were purchased from Home Depot, and kept under grow lights in the classroom. All conditions for the plants were maintained the same: temperature, light, soil, water.

4. A different plant was used for each trial with random leaves being selected. Number of trials = 3. The 3 trials ran at the same time.

5. Solutions were made 10 minutes before the experiment to ensure the Aloe Vera juice wasfresh. Making the Solutions:

Control= Spring Water- Arrowhead to maintain proper osmolarity. a. 1% Stock Solution: 3 mL of fresh Aloe Vera gel extracted from a leaf mixed with 297 mL of Spring Water b. 5% Stock Solution: 15 mL of fresh AloeVera gel extracted from a leaf mixed with 285 mL of Spring Water. c. 10% Stock Solution: 30 of fresh Aloe Vera Gel extracted from a leaf mixed with 270 mL of Spring Water.

Statement of Purpose (Engineering/CS projects)

- **Defines a need/goal/purpose for the project. Involves the development of materials, equipment, or models.**

Examples:

- **The purpose of this computer program is to model the flow of various chemicals through different types of soil and groundwater.**

- **The goal of this project is to develop a Remotely Piloted Vehicle (RPV) that uses the cellular telephone network as a transmission system.**

The Engineering Design Process:

1. Define a need; express a goal
2. Establish design criteria and constraints
3. Evaluate alternative designs
4. Build a prototype of best design
5. Test and evaluate the prototype using design criteria
6. Analyze test results; make changes, and re-test the prototype
7. Communicate the results

During the Breakout rooms, your room leader will show you engineering examples.

Organizing your Results in Tables and Graphs

For both Science and Engineering Projects

- It is necessary to present data in table and graph
- This helps analyze your data with quantitative results

Organizing Results

Page 8 of student notebook

After you collect your data, it is important to organize them!

- **Organizing into Categories**
  - **Helps you interpret what is being observed**
- **Making a Table or Chart**
- **Graphing**
  - **Illustrates relationships in your data**
  - **Helps you visualize your data**

Making a Table

Dependent Variable

Title of Table

Trial labeled

Independent Variable

Growth of Grass			
Week	Total grass height (cm)		
	Trial A	Trial B	Trial C
0	0.50	0.50	0.50
1	1.26	1.01	0.94
2	2.21	1.48	1.13
3	3.52	2.03	1.20

See page 8 of student notebook for finished table!

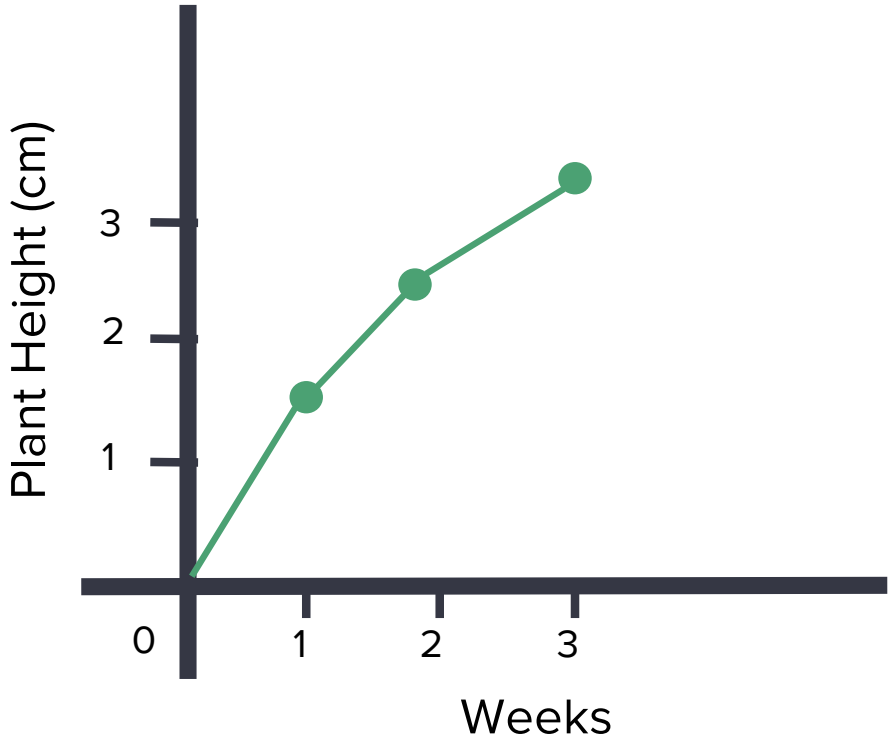
See page 8 of student notebook for finished table!

Making a line Graph from a Table

change of information over a period of time.

A line graph is usually used **to show the**

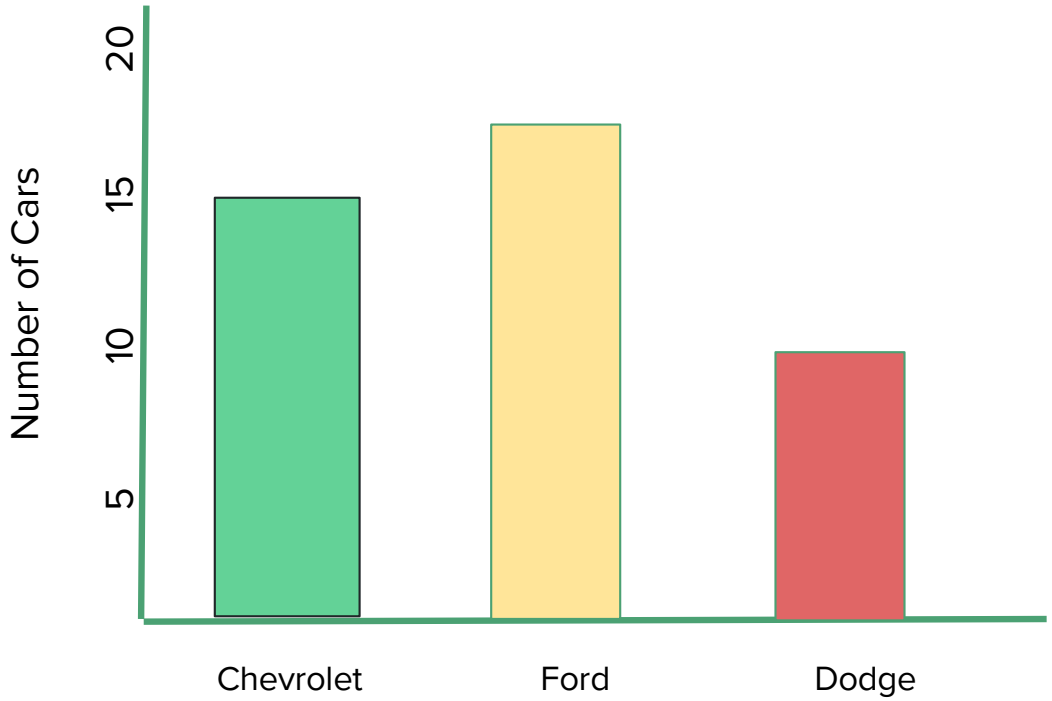
Weeks	Plant Height (cm)
1	1.5
2	2.6
3	3.4



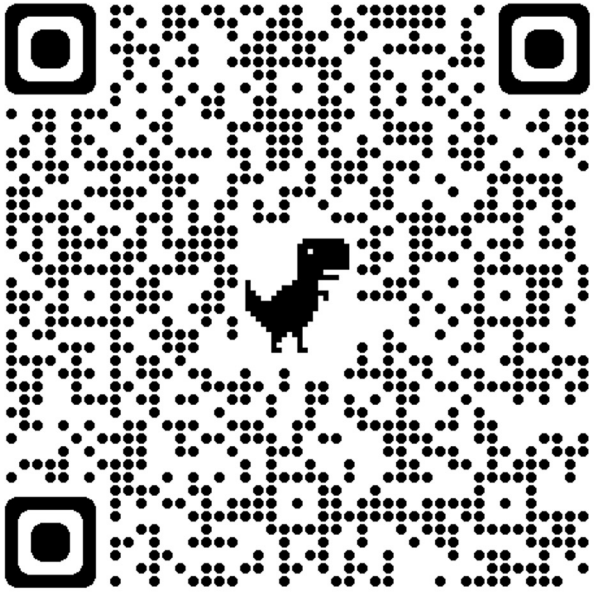
Making a Bar Graph from a Table

Typically used to show categories of information

Type of Car observed	Number of Cars
Chevrolet	15
Ford	17
Dodge	10



We would appreciate your feedback on today's workshop!



https://forms.gle/gG29Zj3Xdb4Y2Fve6

Thanks for coming!

All workshops are 9:30-10:30am

Nov. 12-Data Analysis and Statistics- Basic

Nov. 19 Data Analysis and Statistics- Advanced

Tell your friends!

Email gsdsefslb@gmail.com with questions

If you are interested in joining our mentorship program, sign up here: https://forms.gle/7bxjTaX7Qkd1FmR98