Scientific Design

Scientific Method, Variables

Physical Science

What is Science?

- **Science** is a method for studying the natural world
- It is a process that uses observation and investigation to gain knowledge and develop explanations about events in the natural world
- Scientists ask questions to learn about the natural world
- Scientists use a specific process to investigate their observations. This process is called the **scientific method**.

Scientific Method

1. Make Observations/Purpose:
   - **Observation**: an act of noting or recording an event, characteristics, behavior or anything else detected with instrument or senses.
   - An observation leads to purpose for an experiment. (The purpose of an experiment is always written as a question)

Types of Observations

- **Quantitative observation**: can be expressed in numbers ex. time, temperature, distance, etc.
- **Qualitative observation**: description of sights, sounds, smells and textures.

Quantitative Observations	Qualitative Observations
Photographs or sketches are useful for recording qualitative observations Mass= 30g Mean crystal length = 0.5cm Longest crystal length = 2cm	 Epsom salt crystals Crystals are clear Crystals are long, thin and rectangular. White crust has formed around edge of dish

Observations of Epsom Salt Crystals

Scientific Method

2. Research/Gather Information:

- Gather information in order to formulate a hypothesis and create a valid experiment.

3. Hypothesis

- **prediction**: an expectation of what will be observed or what will happen.

- **hypothesis**: a tentative explanation for an observation or scientific problem that can be tested by further investigation.

Writing a Hypothesis

- Hypotheses are written as "If… then…because statements."
- Ex: Suppose you have two paper airplanes and wonder why one tends to glide farther than the other.

Prediction:	Hypothesis:
If I make a paper airplane with larger wings, then the airplane will glide farther.	**If I make a paper airplane with larger wings, then the airplane will glide farther, because the additional surface area of the wing will produce more lift.**

The "because" part of the hypothesis adds explanation to the prediction.

Scientific Method

4. Test Hypothesis/Run Experiment/Procedure

- Valid experiments must have data that is measurable.
- **Variable** - a quantity that can have more than a single value. (It can change)
  - **Independent Variable** - the variable that is changed to test the effect on the dependent variable.
    (It is what you control/are testing)
  - **Dependent Variable** – changes according to the changes of the independent variable.
    (It tells you if your experiment worked or not)

Scientific Method

- To run a proper experiment, there are two additional concepts that are needed:

  - **Constant** - a factor that does not change when other variable change

    (You control everything but the one variable you are changing)

  - **Control** – the standard by which the test results can be compared

    (It is how you test the variable)

Scientific Method

Example

You might set up an experiment to determine which of three fertilizers helps plants to grow the best. Possible factors that you need to think about include plant type, amount of sunlight, amount of water, temperature, type of soil, and type of fertilizer.

Here is some data to consider….

Scientific Method

Plant	Amount of Water	Amount of Sun	Fertilizer Type	Height after two weeks
A	4 oz. every three days	6hr/day	A	16cm
B	4 oz. every three days	6hr/day	B	14cm
C	4 oz. every three days	6hr/day	C	18cm
D	4 oz. every three days	6hr/day	none	10cm

What is the Independent variable? Fertilizer Type

What is the Dependent variable? Height of the plant ?

Are there any constants? What are they? Amount of water, Amount of Sun

What is the control ? Plant with no fertilizer

Scientific Method

5. Analyze Data (Calculations go here!)

- **Bias:** a slanted point of view or personal prejudice. Bias occurs when what the scientist expects changes how the results are viewed
  - This expectation might cause a scientist to select a result from one trial over those from other trials
- Scientists can lessen bias by running many trials and by keeping accurate observations.

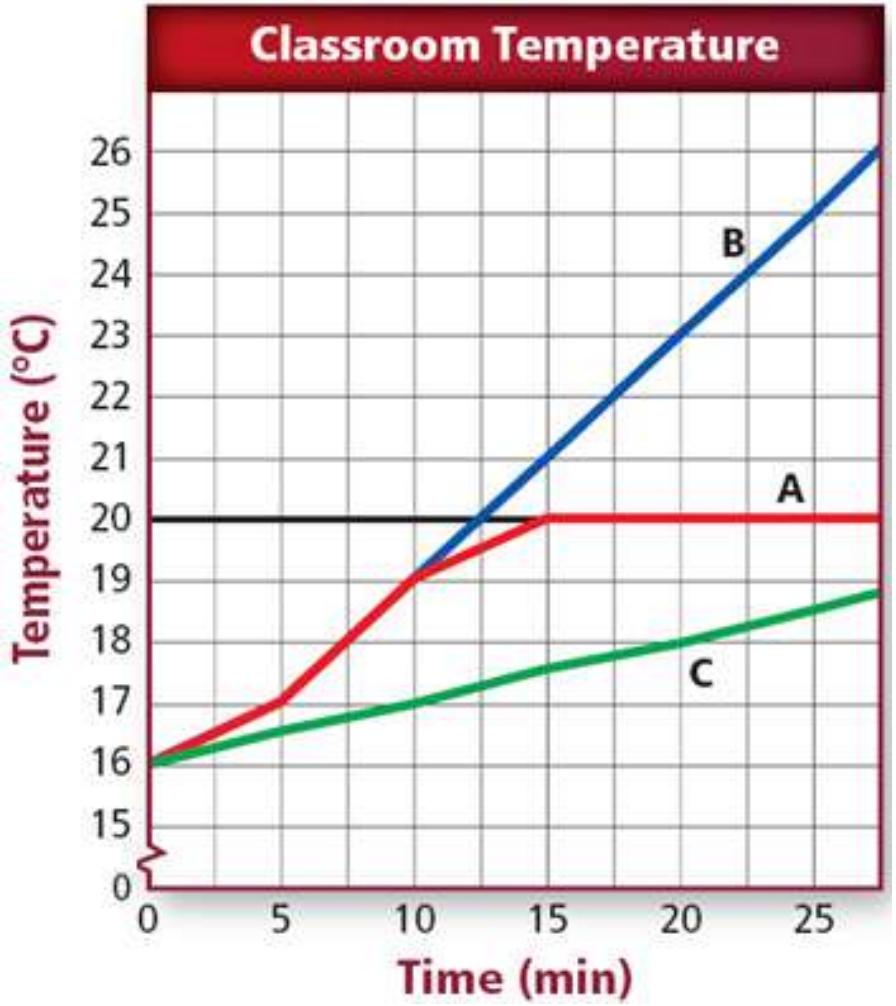
Scientific Method

- An important part of every experiment includes recording observations and organizing the data into easy-to-read tables and graphs
- If the data is not organized in a logical manner, wrong conclusions may be drawn
- A **graph** is a visual display of information or data. Graphs make it easier to understand complex patterns by displaying data in a visual manner.
- Different kinds of graphs - ***line, bar, and circle*** - are appropriate for displaying different types of information

Types of Graphs

Line Graphs

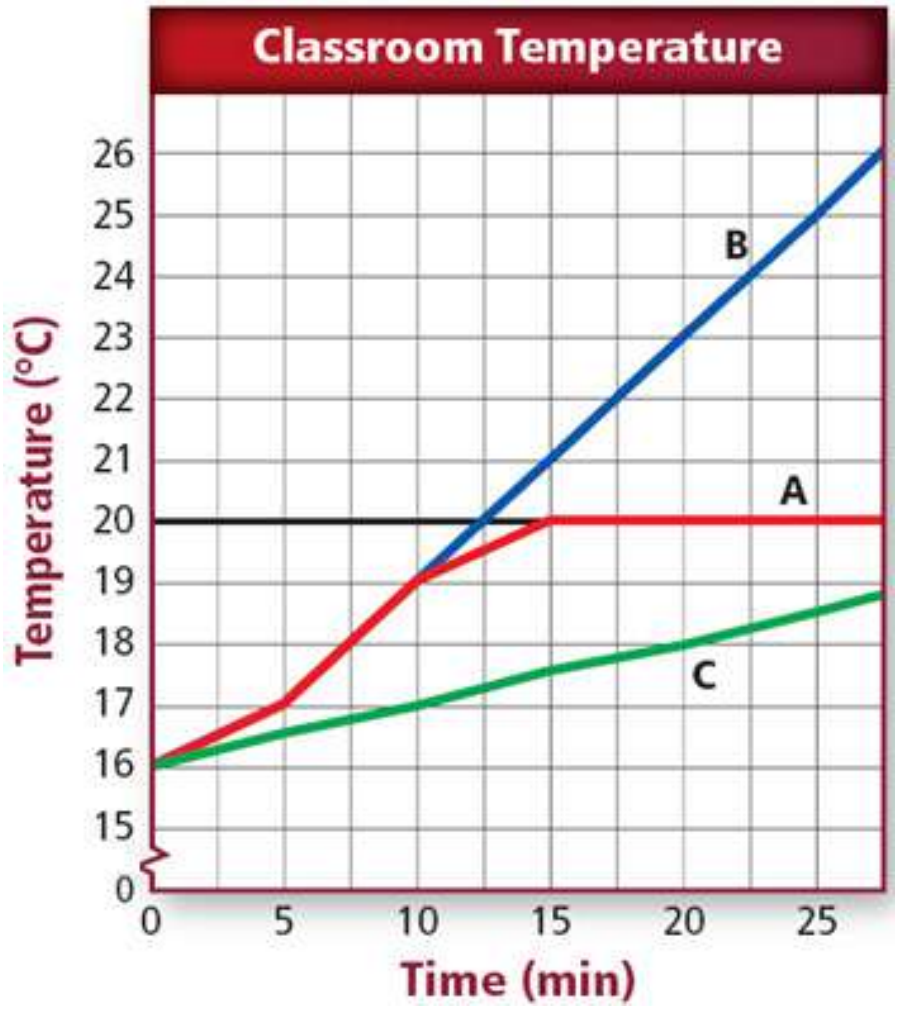
- A line graph can show any relationship where the dependent variable changes due to a change in the independent variable
- If there is time, it is always the independent variable



Types of Graphs

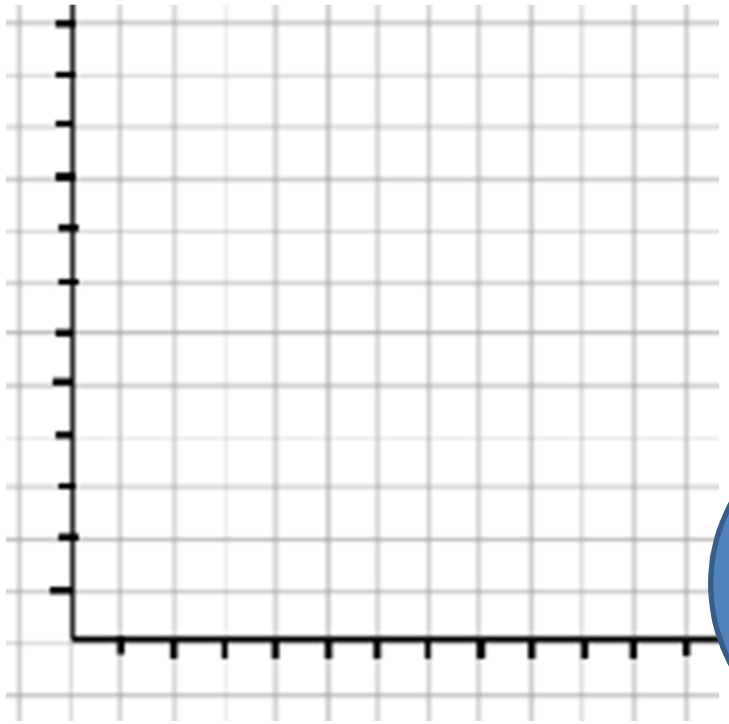
Line Graphs

- The horizontal axis, or the *x*-axis, displays the *independent variable*
- The vertical axis, or the y-axis, displays the *dependent variable*
- Make sure to label the variables and units on both axis's



Graphing Experimental Data

Title – Explains what graph is showing – “relationship between what?”



Dependent Variable (units)

Independent Variable (units)

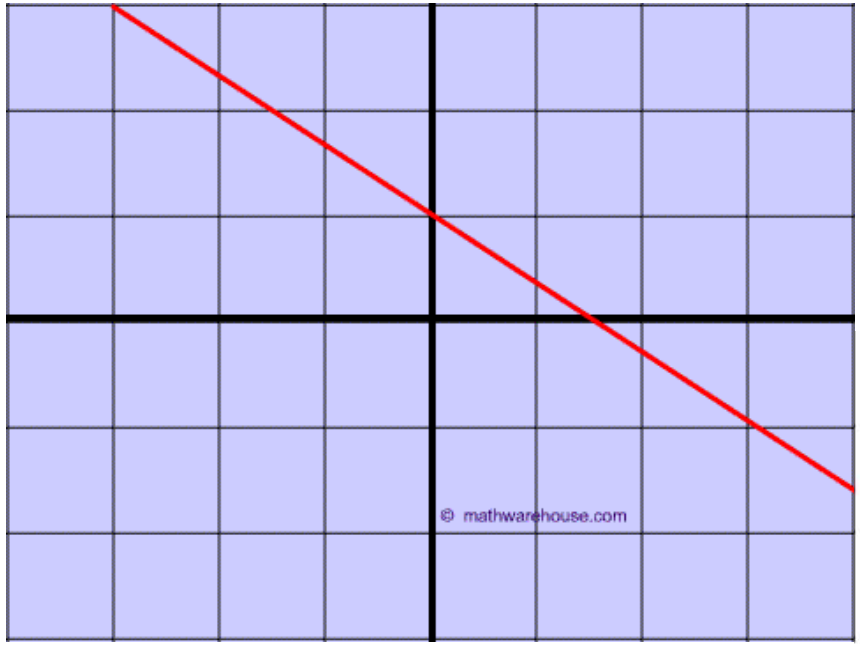
Time (days)	Height (cm)
1	4
2	6
5	9
6	13
9	17

Time is almost always the independent variable

Slope of a Line

- Y=mx+b
  - What do these random letters mean??
- Why do we need slope?
  - The slope of a line is a *rate of change* and is represented by *m.*
  - "rise over run" – change in dependent variable per change in independent variable.
- Two ways to calculate slope:
  - From the graph
  - From 2 points

Slope Practice



1. Start at exact point, count out “rise” (vertical change/change in dependent variable) – Record value
2. Count over to where line intersects another exact point. Record this number as “run” or independent variable change.

- Calculate the slope from the following points: (0, -5) and (3, 5).

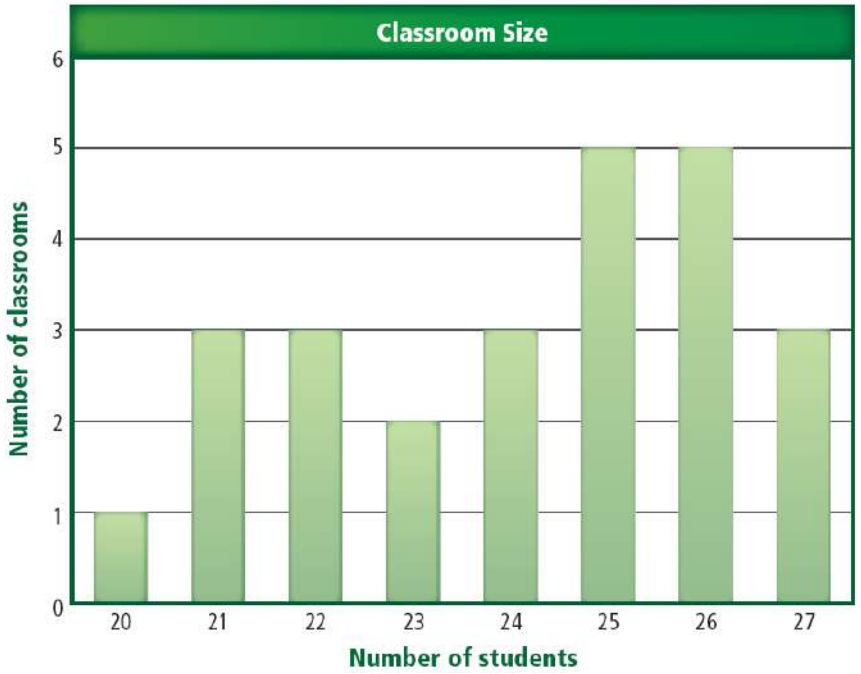
$$slope = \frac{rise}{run} = \frac{y_2 - y_1}{x_2 - x_1}$$

Types of Graphs

Bar Graphs

- A bar graph is useful for *comparing* and *contrasting* information collected by counting

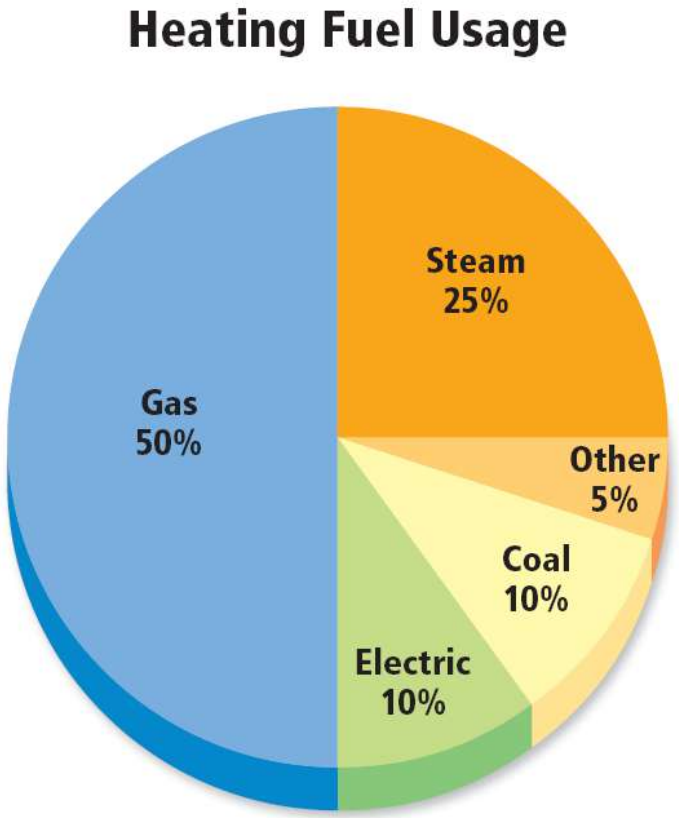
Classroom Size	
Number of Students	Number of Classrooms
20	1
21	3
22	3
23	2
24	3
25	5
26	5
27	3



Types of Graphs

Circle Graphs

- A circle graph, or pie graph, is used to show how some fixed quantity is broken down into parts
- The circular pie represents the *total*
- The slices represent the parts and usually are represented as percentages of the total



Scientific Method

6. Draw Conclusions

- Based on the analysis of your data, you decide whether or not your hypothesis was supported
- For the hypothesis to be considered valid and widely accepted, the experiment must result in similar data every time it is repeated.
- A **scientific theory** is an explanation of things or events based on knowledge gained from many tested hypotheses .
- A **scientific law** is a statement about what happens in nature and that seems to be true *all* the time

After the Experiment

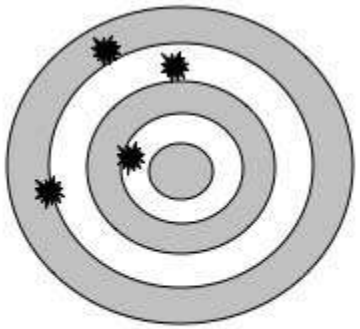
- After completing their experiment, scientists must share their findings.
- Science journals are different than magazines because they are *peer reviewed*.
- **Peer Review**: review by experts in that field for validity as a prerequisite for publishing.
- **Scientific explanations must be supported by evidence and be able to be tested in the natural world!!**

Accuracy and Precision

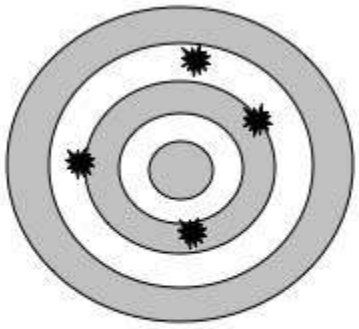
- Accuracy: the **accuracy** of a measurement system is the degree of closeness of measurements of a quantity to that quantity's true value. *How close to actual value.*

- Precision: the closeness of two or more measurements to each other. *How close to other values.*

Accuracy vs. Precision



Not Accurate
Not Precise



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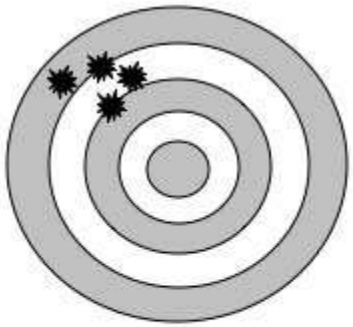

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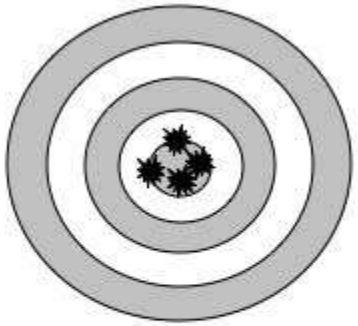

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