EXPLORING SCIENTIFIC PROCEDURES

Exploring Scientific Procedures (ESP) is a method of introducing the concepts of scientific inquiry to students and educators which include:

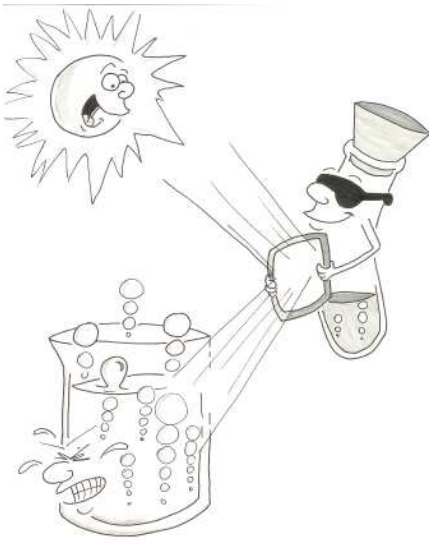
INDEPENDENT/DEPENDENT VARIABLES
HYPOTHESIS BUILDING
CONSTRUCTING DATA TABLES
and
GRAPHING

The materials necessary to perform this method are cheap and easy-to-find and use. Most materials can be found around the home.

This background into the method is intended to train you, the educator, on the basics of scientific inquiry. A rough timeline has been provided within this presentation to guide you through the potential administration of the method to students of various grades.

The proven success of this method has been accomplished through short, weekly activities with students over a long period of time.

ESP should be presented to students much like multiplication facts: in repetitive short bites, spread out over an extended timeframe. Students will begin to see how the independent/dependent variables, hypothesis, data tables and graphs are all related to the process of effective scientific inquiry.



WHAT ESP IS...

ESP is a method to integrate the process of scientific inquiry into your regular science curriculum

ESP encourages problem-solving strategies for students and adults

ESP is low cost !!!

ESP is a discipline that requires time and patience

ESP should be used repetitively, in short amounts, over a long period of time (similar to learning multiplication tables!!!)

WHAT ESP IS NOT...

ESP is not a script to be read
ESP is not a curriculum to be memorized, but a method towards scientific literacy
ESP does not have a standardized timeline
ESP is not exclusively for students
ESP is not a long list of definitions found within a massive textbook
(two definitions are all you need.....)

DEFINITION #1

INDEPENDENT VARIABLE

What you change in the experiment

(to make life easier for your students, you may want this "change" to be measurable – i.e. weight, mass, volume, height, etc..)

DEFINITION #2

DEPENDENT VARIABLE

The result from the change you made

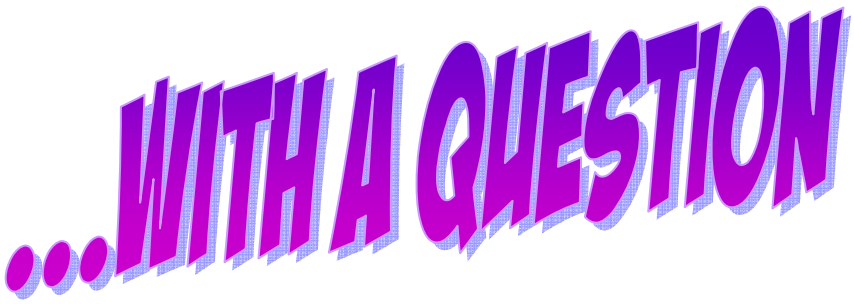
(this variable, also known as data, "depends" on your independent variable and, again, should be measurable !!!)

THE INDEPENDENT VARIABLE AND THE DEPENDENT VARIABLE ARE CLOSE RELATIVES AND CAN BE FOUND THROUGHOUT THE FOLLOWING STEPS OF SCIENTIFIC INQUIRY:

QUESTIONS
HYPOTHESIS
DATA TABLES
and
GRAPHS

All scientific experiments begin with simple questions….

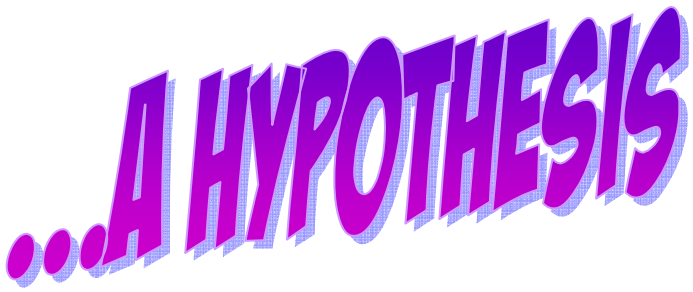
It is this sense of inquiry that ESP begins its journey….



QUESTION

Does the _____ affect the _____?
(Independent Variable) *(Dependent Variable)*

Now that you've asked a QUESTION, it is time to change it into a measurable and educated guess….



HYPOTHESIS

If the _____ is _____,
(Independent Variable) *(increased/decreased)*

then the _____ will _____.
(Dependent Variable) *(increase/decrease)*

All data that is collected within an experiment must be in an easy format for future study. The following data table should remain the same throughout each of your student's experiments. With practice, they will become very proficient in recording data that can be easily analyzed.

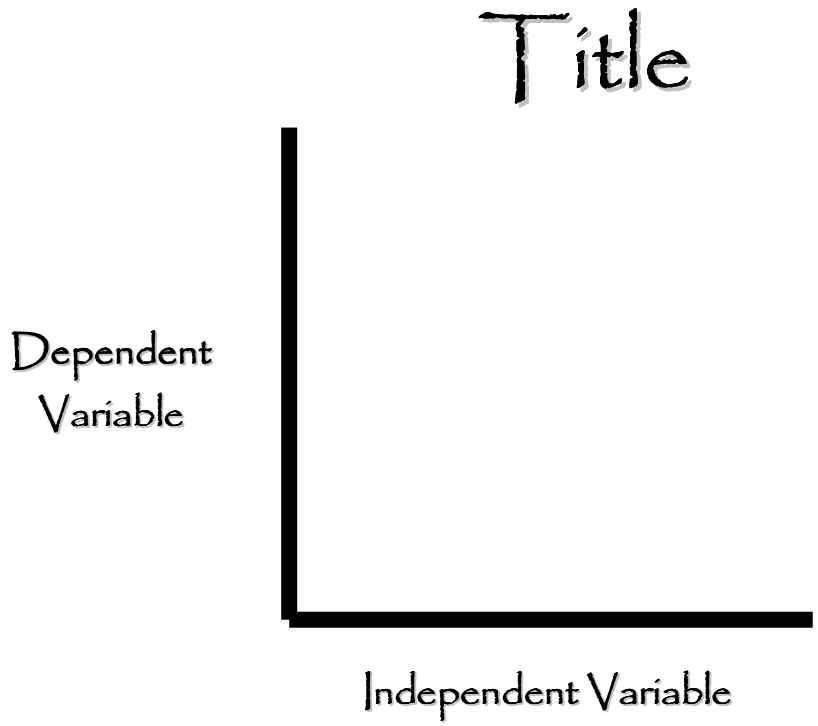
Independent Variable	Dependent Variable			
	Trial One	Trial Two	Trial Three	Average

While analyzing the data in an experiment, you are typically looking for patterns and relationships between what you are changing (the independent variable) and your data (the dependent variable).

A GRAPH CAN HELP VISUALIZE THE DATA IN A WAY THAT IS EASIER TO SEE ANY OF THESE POSSIBLE RELATIONSHIPS.

THE TITLE OF ANY GRAPH SHOULD RESTATE THE HYPOTHESIS OF THE EXPERIMENT….

….THIS HELPS THE PERSON WHO IS READING YOUR GRAPH TO EASILY IDENTIFY WHAT THE DATA IS ALL ABOUT!!!



GRAPH TITLES

The effect of the _____
(Independent Variable)
on the _____.
(Dependent Variable)

STUDENTS MUST SEE THE INDEPENDENT VARIABLE AND THE DEPENDENT VARIABLE IN THE

QUESTIONS
HYPOTHESIS
DATA TABLES
and
GRAPHS

LET'S TRY AN EXAMPLE...

Question:

Does the distance a rubber band is pulled back affect the distance a rubber band can travel?

Can you identify the Independent and Dependant variables?
IV = …distance a rubber band is pulled back
DV = …distance a rubber band can travel

LOOK FOR THESE PHRASES THROUGHOUT THE EXAMPLE !!!

Hypothesis:

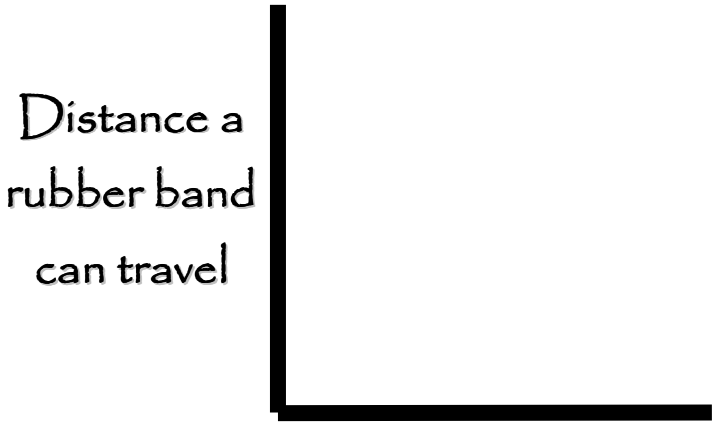
If the distance a rubber band is pulled back is increased, then the distance a rubber band can travel will decrease.

Data Table:

Distance a rubberband is pulled back	Distance a rubber band can travel			
	Trial One	Trial Two	Trial Three	Average

Graph:

The effect of the distance a rubberband is pulled back on the distance a rubberband can travel



THE PHRASES…

"distance a rubber band is pulled back"

and

"distance a rubber band can travel"

CAN BE SEEN THROUGHOUT THE ENTIRE EXPERIMENT!!!

YOU NEVER CHANGE THE PHRASES…

THEREFORE, THE STUDENT WILL EASILY SEE THE RELATIONSHIPS BETWEEN THE:

QUESTIONS
HYPOTHESIS
DATA TABLES
and
GRAPHS

Have your students explore one activity a week. At first, provide them with a question, a hypothesis a data table and a graph…

…after a few weeks, ask your student to start writing their own hypothesis from your question. In addition, have them set up their own data table and graph before starting the experiment. With weekly repetition, students will be able to effectively set up, run and analyze the results of a scientific experiment!!!!

MORE IMPORTANTLY, EACH EXPERIMENT CAN BE USED TO REINFORCE THE SCIENTIFIC CONCEPT YOUR STUDENT IS CURRENTLY LEARNING.

For example…..

If your students are learning about how energy can be transferred from potential to kinetic, you can use the rubber band experiment to reinforce this concept….

…and while they are learning about the transfer of potential energy to kinetic energy, they are also practicing effective scientific inquiry procedures !!!

Once your students become more proficient at this model….

YOU CAN REALLY START HAVING FUN WITH THEM…

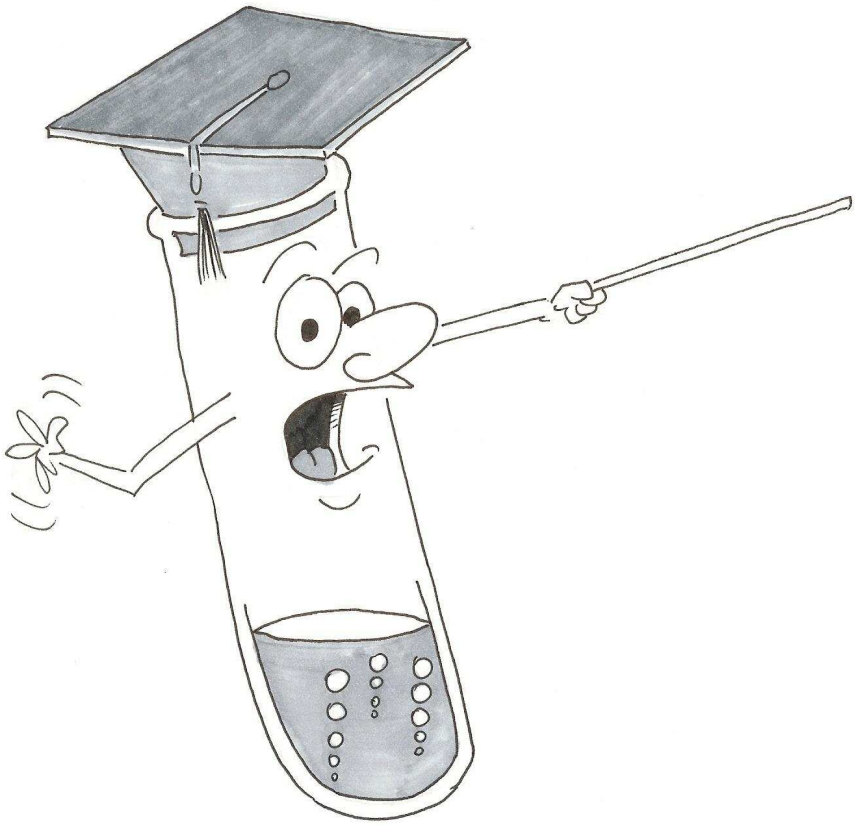
SOURCES OF ERROR

HAVE THE STUDENTS LIST:

All of the materials used in the experiment
(i.e. ruler, rubberband, etc.)

and

All of the possible ways the materials could have been changed (each of which is a "SOE") (i.e. size, shape, color of rubber band, angle of the launch, presence of wind, etc…



All materials in an experiment must remain **CONSTANT**

The possible changes in materials identify sources of error (SOE) that could alter the results of an experiment

Constants are very important because you only want to change <u>ONE</u> variable in your experiment!!!

WHY DO YOU ONLY WANT TO CHANGE ONE THING IN YOUR EXPERIMENT?

So that you can identify what variable is altering the results in your experiment…..

….if you changed two variables, how would you know which one is affecting the results???

CONSTANTS *share their importance with another factor in experiments..*

THE CONTROL

THE CONTROL IS A TRIAL WITHIN YOUR EXPERIMENT THAT IS USED TO IDENTIFY ANY UNKNOWN SOE'S THAT MAY BE AFFECTING YOUR DATA

For example…

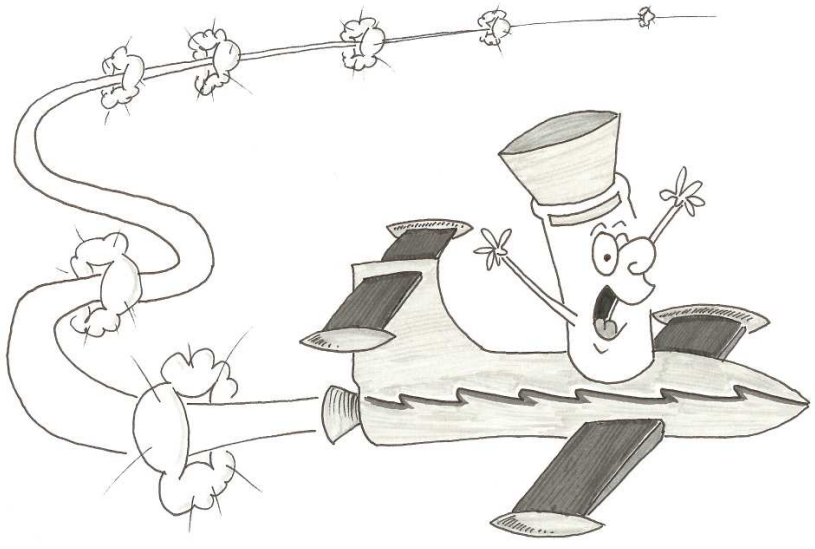
If your student wishes to see the effects of salt water on the growth rate of plants, the CONTROL in this experiment would be to use ordinary water with their plants to gauge the normal growth rate. Along with this CONTROL, the student will grow other plants with varying levels of salt water…

If all the plants die, with the exception of the CONTROL, you may assume that the salt is the culprit!!!

If even the CONTROL perishes, you may have an unknown SOE in the water that needs to be identified.

THE CONTROL IS THE NORMAL EXPECTATION OF WHAT IS TO HAPPEN

Typically, you tend to already know what to expect with your CONTROL, but you run the trials anyway…just to be certain there are no hidden SOE's that could affect your results.



GRADE LEVEL EXPECTATIONS

The Grade Level Expectations provide you, the educator, a rough timeline of what to expect from your students according to their grade level.

Naturally, each student progresses at different levels. These Expectations may, of course, be modified to meet the individual needs of your learners.

The pre-designed lab sheets found in the back of this resource booklet describe a standardized path by which to follow in teaching your student. They have been categorized by grade to assist you in your curriculum development.

SO WHAT DO YOU DO WHEN YOUR STUDENT IS VERY COMFORTABLE WITH SETTING UP, RUNNING AND ANALYZING THE RESULTS FROM AN EXPERIMENT???

QMS Strategy

THE QMS STANDS FOR:

QUESTION
METHOD
SOLUTION

Consider the QMS Strategy as the "challenge phase" of this method…..

Up to this time, you have been providing your students with the Question to solve in their experiments

NOW, LET'S CHANGE THE PROCEDURE A BIT…

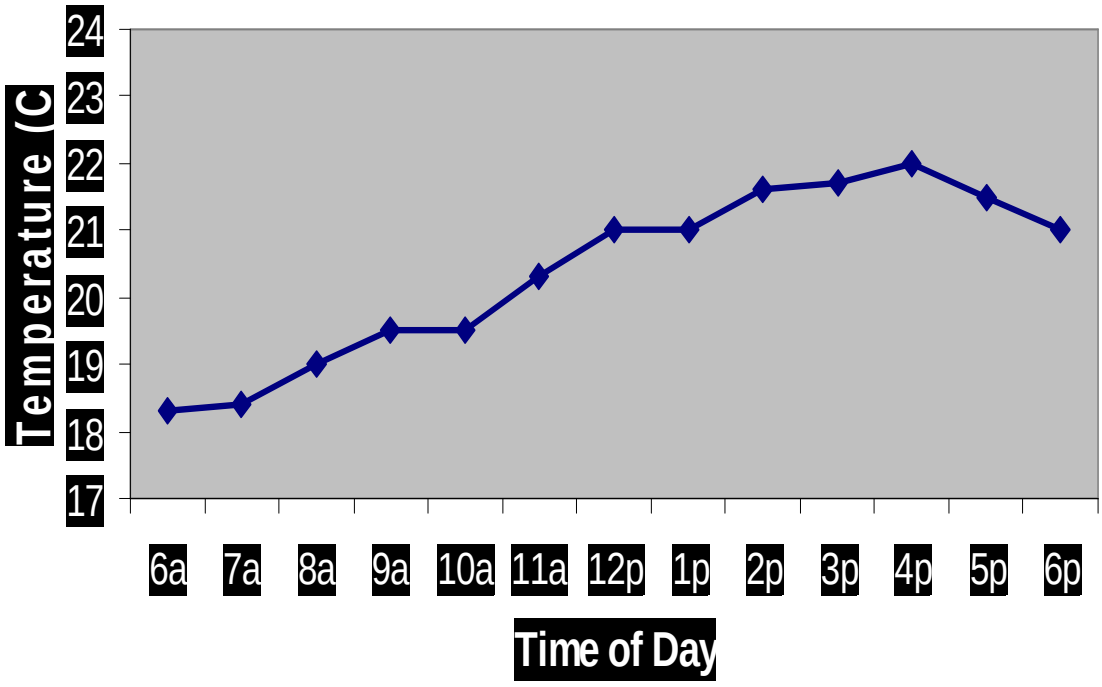
Instead of providing the question to your students, now provide the Method (a procedure) or Results (a data table or graph) for them to follow….

- FOR EXAMPLE -

By providing a completed graph to your students, or perhaps a procedure, your students can be asked to determine the experimental:

QUESTION
HYPOTHESIS
DATA TABLE
CONCLUSION

BY PROVIDING A GRAPH SUCH AS THIS:



The Independent and Dependent Variables can be identified……

…. and can be used to create a question and a hypothesis such as these:

QUESTION:

Does the time of day affect its temperature?

HYPOTHESIS:

If the time of day is increased, then the temperature will increase/decrease.

. . . .AND A DATA TABLE SUCH AS THIS:

Time of day	Temperature			
	Trial One	Trial Two	Trial Three	Average
8am				
Noon				
4pm				

The QMS Strategy forces the student to look at an experiment from a more practical way…

AS A PROBLEM TO SOLVE!!!

DO NOT FORGET !!!

YOU REALLY CANNOT BE "WRONG" IN RUNNING A SCIENTIFIC EXPERIMENT...AS LONG AS YOU CAN DEFEND YOUR DATA.

IT DOES NOT MATTER IF YOUR DATA SUPPORTS OR DOES NOT SUPPORT THE HYPOTHESIS; EACH EXPERIMENT SHOULD SET THE STAGE FOR FURTHER EXPERIMENTS TO EXPLORE.