Elementary Science Inquiry

Red font: teacher suggestions; remove to create student handout.

Investigation (teacher provided):

Phrase the investigation so that it is open ended. Some examples are:

- Investigate factors that affect shadow size
- Investigate factors that affect plant growth
- Investigate factors that affect angle of reflection
- Investigate factors that affect the solubility of salt in water

Problem: What is the effect of (manipulated variable) on (responding variable) when.....?

Allow students to determine their own variables.
The ***manipulated variable*** is changed by experimenter in a logical manner.
Examples from above respectively are: time of day, volume of water added, medium that light travels in, amount of stirring etc.
The ***responding variable*** is measured - if it is a quantitative lab then a tool is used, if it is a qualitative lab then a reproducible scale is used (like a grey scale if measuring colour density etc.)
Examples from above respectively are: length of shadow in cm, height of seedling in cm, mass of salt dissolved in g.
The ***control variables*** must remain constant and must be relevant to the success of the experiment. I would recommend at least three.

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Manipulated variable: the variable that is changed by the scientist (in a logical manner).

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Responding variable: the variable that responds to the changes - usually measure with a tool.

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Controlled variables: the variables that must stay constant to ensure the data is trustworthy.

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Prediction: Make an educated guess with some kind of explanation.
Don't allow students to use the computers for these investigations so that you know the planning is authentic. I would recommend that all students in the group record all of the information. This amount of work takes a significant amount of time especially if the students are new to the process. I would suggest an hour for just the collaborative planning process including the prediction. Initial the first page before the students begin the procedure to ensure that they have selected the variables correctly.

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Materials: What materials will you use? List all required materials including their sizes and the number you need. Ex: 250 mL beaker ____
A comprehensive list of all materials required for the experiment.

Procedure: Use numbered steps (as many as necessary) to outline the procedure. Diagrams are helpful.

1.
2.
3.
(keep going if you need more steps)

At this point students should do some peer review. Groups should switch procedures to ensure that the procedure is easy to follow and reproducible. Teacher should also initial this before proceeding and before allowing students access to any equipment.
Students need to complete the data collection table before beginning the experiment.

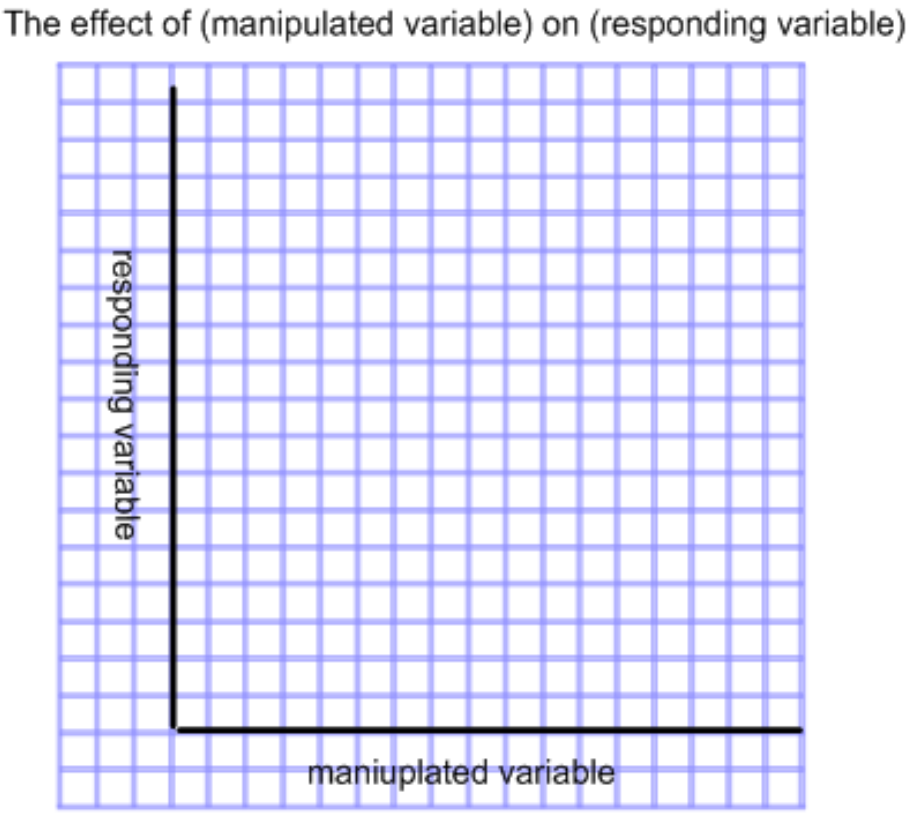
Data Collection: Create a table:

Title: The effect of (manipulated variable) on (responding variable).

(Manipulated Variable) with units	(Responding Variable) with units	Other Observations

Notice that the title format is the same as the problem format. This allows easy title creation and is consistent with the variables chosen. Other observations refers to qualitative observations that were noticed if the lab was only quantitative.

Data Analysis: Decide how to show the data so that the reader can make meaning of the results. It can be in a graph format followed up by calculations if required.



*Manipulated variable on x-axis, responding variable on y-axis, don't forget the title.

Students choose how to graph their data depending on their results. Maybe a graph isn't suitable. If they choose a graph, is it a line graph, a bar graph, a scatter plot? Maybe it is a pie chart. It is up to them.

Conclusion and Evaluation:
The conclusion needs the following:

1. Restate the results:
   Restate the results by answering the problem with the format, "The effect of (manipulated variable) on (responding variable) was shown to be....."
2. Evaluate the design:

   a. List the systematic errors and the effect they had on the results:
   List systematic errors that occurred (errors from their system's design) and describe the effects they had on the results - specific effects such as we used **too much water** in our design when watering the seedlings so that **they lost mass** as they began to die. Remember, it is okay for designs not to work because of design flaws. This happens all of the time and students need to be aware that success does not occur often in science research. None of this should be hypothetical; the errors stated actually occurred.
   b. List the random errors
   These errors are not because of the design. They are human errors or errors that occurred where you could not predict their effect on the result. It is difficult to find these at the elementary level so you can omit this if you want. At the secondary level, generally these errors are equipment based.
   c. Describe improvements to the procedure that could fix the systematic errors listed:
   Specify improvements to the design that would fix the systematic error. For example, if the water volume was halved in the experiment to the volumes of 5 mL, 10 mL and 15 mL, the plants should gain mass.
   d. Describe a new investigation that interests me: