Mission Debriefing: Teacher Guide

Activity 2: Design It

Students will use the help of a brainstorming method to guide them in the scientific method as they design and carry out their own bacterial experiment.

This experiment can be used following Activity 1: Me as a Scientist OR it can be used independently of the other lab.

Learning Objective:
Students design and carry out their own experiment using bacterial cultures as their starting point. They not only gain understanding of the nature of bacteria colonies and their response to a variable change, but also learn to apply independent and dependent variables as they develop a problem question and hypothesis for their experiment.

Background:

Background information on bacteria is found in Activity 1: Me as a Scientist.

Experimental design is part of the inquiry approach in teaching science. When students are the ones developing the inquiry activity, instead of being guided by the teacher, they truly begin to understand the process. At times, teachers avoid this because it can feel scary to let go of the “control” and have all of the students doing something different. Sometimes teachers put a lot of emphasis on the product in experimentation as in a science fair type approach. That can be quite overwhelming for students and teachers and parents. But, with this Design It approach, students develop their experimental design plan themselves. They understand it and really enjoy it! The Scientific Method Planning Form with Post-It Notes handout keeps them focused on their independent, dependent, and controlled variables which can be a source of great confusion during the experimental design process. It helps students see how they can record their observations in both data table and graphical formats. And, they learn how to write great conclusions. The guidelines that follow explain how to model the procedure page by page. At the end of this section, some ideas are shared on how to apply this method to other experimental areas. The focus is on the process. A final, formal write-up would be an option sometimes, but a well edited rough draft can still provide a good assessment of the learning process without the stress and time spent on a final draft.

This Scientific Method Planning Form with Post-It Notes handout is based on a six step scientific method of 1) Problem Question, 2) Information gathering, 3) Hypothesis, 4) Experiment, 5) Results, and 6) Conclusion (a handout of this is included for your optional use). It will work equally well with whatever method you/your school/your curriculum uses; you will just need to adjust the form accordingly.
Typically, an overhead transparency or other display mode is used by the teacher, while the students have their own packet handouts and follow along. The teacher writes on the transparency, while the students use their Post-It Notes and move them along throughout the process.

Page 29: Give students a handout of pages 29-36. They also need 4 small “lighter” colored Post-It notes and 4 small “darker” colored Post-It notes. Have students put the “lighter” colored Post-Its on the top 4 squares of page 29. Then, the “darker” 4 Post-Its will go on the bottom 4 squares. Introduce a general topic to narrow the investigation. (This is important the first few times you use this method, plus it allows you to fit the experimentation with your unit of study. In a science fair type planning session, the topic could be totally open to any field of science study.) For this example, we will use “Exercise and the Body” for the general topic. Next, ask students to put themselves in the role of the scientist planning the experiment and think of some things they could change or vary on purpose. Items often mentioned are changing the number of exercises, changing the length of time of the exercises, changing the type of exercise, changing the gender of those doing the exercise, changing the intensity level of the exercise, changing the surface where the exercise is performed, and so forth. They should write one of those items on each of the top four Post-It Notes while the teacher fills in the overhead transparency. For the modeling situation, have the whole class write the same things. Next, ask the students to think of things the scientist could measure or observe that are different from the list above. Things they often mention are heart rate, respiratory rate, blood pressure, and calories used.

Page 30: On this page, the scientists will choose their variables. As a class, decide on one of the “change on purpose” Post-It Notes (length of time of exercise is a good one) and have students move that Post-It Note to page 30, where it says “Part to change.” Tell students this becomes our independent variable in our experiment—the one we choose to change on purpose. Then choose a Post-it note from the bottom of page 29 in the “measure or observe” section (heart rate is a good one). This becomes our experimental dependent variable—the one we will measure or observe (a change in). Have them transfer that Post-It Note to the correct section on page 30. Finally, return to page 29 and move all the remaining Post-It Notes to the bottom of page 30. Explain that these become the controlled variables, the things we make sure we “control so they don’t change. We keep them the same throughout the experiment—to the best of our ability.” This is a good point to explain to students that given enough time or equipment, we could test most of the variables chosen. As we experiment in the classroom, we will limit ourselves to the available supplies and choose experiments that work within a certain time frame. So, that would eliminate choosing “calories used” from our list. We might also want to eliminate blood pressure since most classrooms don’t have access to enough blood pressure equipment.

Page 31: Next, we will use our chosen variables to write our problem question. Have students transfer the independent and dependent Post-It Notes to their page 31 squares. Then fill in the appropriate words to make the sentence read “How does changing the quantity of exercise affect the heart rate?” On the bottom of page 31, help student to brainstorm some of the categories they might need to formally or informally research in order to make an informed prediction/educated guess in their hypothesis. Some
commonly mentioned categories are as follows: learn about the heart, learn how the heart responds to an increase in activity, learn about types of exercises, and so forth. Much of a scientist’s time is spent in this stage where they learn other things that are already known about their proposed problem question. That is why it is included here. In some situations, it is suitable to allow research time in the library, while in other cases the class may verbally share some things they know or read some background information in their textbook.

**Page 32:** Again, students transfer their Post-It Notes while the teacher writes them on the overhead. This step is where the hypothesis or “educated guess” is developed. The hypothesis always involves stating a prediction about what will happen to the dependent variable when the independent variable is changed on purpose. Complete the sentence at the bottom by filling in the blanks. In the example case, it could say “If the length of exercise time is increased, then the heart rate will increase.” Remind students that this step is the prediction of what the answer might be for the Step 1 Problem Step, but get as specific as possible in this step.

**Page 33:** Creating an Experiment plan is next. Begin by explaining they should list the materials they might need to complete their experiment. In this case, there isn’t much needed other than people to do the exercises and a stop watch or clock. Then demonstrate to the students how to create a step-by-step plan for their experiment. They can generate suggestions and the teacher guides the discussion to get to something similar to the following: 1) Have 5 people take their resting heart rate. Record in the data table. 2) Have the five people do jumping jacks for 30 seconds at their normal pace. Take their heart rate. Record. 3) Allow their heart rates to return to the resting heart rate level. Have them do jumping jacks for 60 seconds at their normal pace. Take their heart rate. Record. 4) Allow their heart rates to return to the resting heart rate level. Have them do jumping jacks for 90 seconds at their normal pace. Take their heart rate. Record.

**Page 34:** This step of the scientific method involves designing a data table to record the experimental information. We are rarely taught how to do this, so it is actually a good thinking skill for students. Data tables can vary a lot depending on what data needs to be collected and allowing a spot for the various trials and an average and totals column, if needed. But, if students will begin with their independent variable in the left hand column and their dependent in the right hand column, things will usually fall in place more easily. Have students transfer their Post-It Note. Again, students see that the independent and dependent variables are the thread that runs throughout the experiment. In this experiment, the data table would have “Length of time for exercises” in the left hand column with three options below: 30 seconds, 60 seconds, and 90 seconds. In the right hand column should be Person 1, Person 2, etc. This is where it can be pointed out that the more trials, the more reliable the data. It takes at least 5 trials for data to be considered reliable, although actual scientific investigations involve thousands of trials. In this case, we could consider five different people as being our trials, or even better, each of those five people could do another trial or two. It is helpful at this point to demonstrate this to students by writing trial 1, trial 2, and trial 3 under the dependent variable column. Then add a column to the right for total and average.
Page 35: This page is a continuation of the Results step. Data is usually displayed in a visual manner of some sort because it makes it easy to interpret at a glance, whereas a data table takes lots of study to figure out a trend in data. Have students transfer their independent and dependent Post-It Notes. Notice the easy way to build a title for the graph by filling in the independent and dependent graph blanks. Certainly, this is not the only way to title the graph correctly, but it helps students see the importance of keeping the focus on the interaction of the variables. A bar graph would be a good choice here. Graphing just the average of multiple trials is usually the best way to display data.

Note: A bar graph is typically used where the information is a comparison and a line graph is better when the data is connected, as in something happening over time.

Page 36: Writing a conclusion…this becomes much easier when students are guided into including the six points that follow. Scientific conclusions are not creative writing experiences. They just reflect the facts. They should be written in third person without the use of personal pronouns. That takes some getting used to, but usually just involves replacing the “I, our, we” pronouns with “the”. Conclusions can become rather “formulaic” seeming but that is okay for a scientific write-up. And, students will get very good at writing quality conclusions very quickly with just a little practice at this. Finally, have students transfer any of their Post-It Notes, even from page one, to see what things they could change to create a new problem question for further study. Many combinations are possible. In this situation, students might propose to change their variables to the “type of exercise” and see how that affects “heart rate.”

A cool way to help students understand terminology:
Because remembering independent and dependent variable definitions can be difficult for students, using the following “hand” memory device is useful. It not only helps students define the terms, but it can be used to show students where to place these variables as they create a graph of their data.

Helpful Hint on where to place variable on a graph:
Put your left hand up, thumb out. Your fingers represent the “dependent” variable and the thumb is by itself - “independent.” Remember that you put your thumb out “on purpose” which is a hint for the independent variable.
Materials:

For each group of 2-3:

For the presentation:
- Scientific Method Planning Form with Post-It Notes handout for each student
- 4 small Post-It notes of a lighter color AND 4 small Post-It notes of a darker color for each student

For the experiment:
- 2-3 Petri dishes per group (See Activity 1: Me As a Scientist, for methods on pouring the agar and ordering the dishes.) Students who can test their variables in several locations on one Petri dish might only need two plates, whereas students who change temperature or light conditions will need three. It is perfectly acceptable to guide students into planning experiments that don’t require excessive use of supplies.
- Various supplies depending on the problem question each group develops
- Bacterial cultures from a scientific supply house (Three types are recommended in case students choose “type of bacteria” as their variable to change; students who choose other variables should choose just one of the samples and use the SAME type of bacteria on all their culture plates. Most science supply houses will offer bacterial cultures for around $10 for enough to do a class of 30. For 120 students working in groups, it probably would be fine to just order three tubes. They seem to go much farther than indicated. Flinnsci.com and Carolina.com both have several choices. Hunt for bacteria that grow on Nutrient Agar between 25-30 °C. Some suggested types are *Bacillus cereus*, *Serratia marcescens* (reddish pigment), and *Bacillus subtilis* but many other types will work well also. Starting with one type of bacteria will give an even growth on a Petri plate so other variables may be easily changed while keeping the bacterial growth the same.

Procedure:

1. Instruct students on the use of the Scientific Method Planning Form with Post-It Notes. (See Background section.) Students can save this and reuse it throughout the year on other experimental design plans, or you can have a classroom set to use.
2. Divide the students into groups of two or three. Allow them to brainstorm using the Scientific Method Planning Form with Post-It Notes handout in their group. Following the brainstorming session with a class sharing time often allows “stuck” groups to develop and idea and it allows some good instructional time for ideas that have gone off track. Some ideas students often choose as variables are as follows:
   - Changing the temperature of the incubation location (a light or a heating pad can be a source for warming)
   - Changing a disinfectant (see activity 1)
   - Changing the incubation light levels, bright, medium, dark or the type of light, fluorescent, incandescent, colored
   - Changing the type of growth medium or the agar concentration (note: certain bacteria prefer specific types of mediums, nutrient agar is a general type)
   - Introducing salt or other nutrients to the growth medium
• Changing the type of bacteria (if students choose this, they need to make sure it is the only variable they change and everything else stays the same, you will need to order three different types of bacterial cultures)

3. Each student should develop Steps 1-4 on their own notebook paper or in their journals, although they will work as a group to do this. They should plan their Problem, Information (student decides what to research), Hypothesis, and Experiment steps and turn those in for approval (See Notes: Scientific Method handout that follows). Have students hand in their pre-plan paper clipped together as a group with the best one on top. Then, the teacher only has to make corrections on the top paper and the other students can be directed to correct their rough drafts when you return the papers. The teacher can decide what supplies she will provide and inform students of those; students should bring any additional supplies a few days before the designated experiment day. The teacher will guide students in making choices that work within safety parameters, time frames given, and equipment limitations.

4. After approval, they should design a Step 5—Results, data table for use in collecting their observations. It is helpful to give them some in class research time for Step 2—Information gathering also, but this step could be assigned as homework. Ideally, they would do their research before creating their hypothesis, but that would require collecting Steps 1 and 2 first. They usually need some guidance on what to research. If time allows, this certainly would be a good way to approach this. Otherwise, it works to collect Steps 1-4 at one time.

5. On the pre-assigned day, students will be provided with Petri dishes and other supplies the teacher provides. They have supplied other items they determined they will need for their experimental plan. Remind them to label their dishes. Additional observation days will be needed for students to complete their data collection. Communicate acceptable time frames ahead of time (although all of that should be written into their experimental plan).

6. After their data collection is complete, students will complete Step 5 by creating a graph. Occasionally, the data does not fit a quantitative graph format. Another type of visual display of the results can be used in these cases, but a teacher may need to help these groups individually.

7. Step 6 will involve the students completing their conclusion.

8. A formal, final draft of the experiment may be required by the teacher or credit can be given for a corrected rough draft which still indicates student learning.

9. The following are included at the end of the teacher section for optional use.
   • Scientific Method: Notes
   • Data Table Self Check and a Graphing Self Check
   • Modified Lab Write-up Form

Extension Activities:

**Physical Science:** Other topics that lend themselves to experimental design are exploring the effects of various variables on melting points, pendulum variables, density, simple machines, convex and concave lenses, pH, and insulators.

**Earth Science:** Other topics that lend themselves to experimental design are soil comparisons and characteristics, weathering rates, solar energy interactions, effects of wind/shade on temperature, and the effect of various changes on erosion rates.

**Life Science:** Other topics that lend themselves to experimental design are plants (students grow pinto bean seeds or radish seeds or others to test variables) or invertebrates (students use several simple invertebrates such as crickets, roly polys also called pill bugs, hissing cockroaches, earthworms, etc. and they use one species or a combination of species to design their experiments).

**Technology:** Incorporate technology into experimental design by having students create a movie using a flip camera showing the various stages of their experiment. Check out [http://www.digitalwish.com/dw/digitalwish/view_lesson_plans?id=5888](http://www.digitalwish.com/dw/digitalwish/view_lesson_plans?id=5888) for more information.

Standards:

**National Science Education Standards, Grades 5-8**

**Science As Inquiry**

**Content Standard A**
As a result of activities in grades 5-8, all students should develop
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Web sites:

Site with information on growing cultures and mixing agar medium

Ordering bacterial cultures and disposable Petri dishes:
Mission Debriefing: Student Activity Sheet

Design It

Investigating Scientists ________________________________

Scientific Method Planning Form

Planning Step #1: Brainstorming
Place Post It Notes in the squares below.

General Topic: __________________________________________

Things the scientist could change or vary on purpose:

__________________________________________

__________________________________________

__________________________________________

Things the scientist could measure or observe (different from above):

__________________________________________

__________________________________________

__________________________________________

__________________________________________
Planning Step #2: Choosing Variables
Place Post It Notes in the squares below.

Part to change (independent variable):

Part to measure (dependent variable):

Part or parts to keep the same, where possible (controlled variables or constants):
### Step 1: Problem
What is the question this experiment will try to answer? Include the independent and dependent variables in the question. For Example: *What fertilizer (independent variable) will grow a bean plant to the tallest height (dependent variable)?*

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Dependent Variable</th>
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### Step 2: Information
What **background information** will be helpful to know?
Step 3: Hypothesis

If the independent variable changes...

...then this is what will happen to the dependent variable.

Write your hypothesis below, using the boxes above as a guide.

If the _____________________________ is _____________________________,
then the _____________________________ will _____________________________.

Independent Variable

Dependent Variable

Independent variable

dependent variable

describe how you will change it
describe the effect of the change
Step 4: Experiment
Write out your experimental plan.

Materials List:  Safety Precautions:  Preparation:

Step-by-step instructions (like a recipe):

____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
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Record your data in the data table below:

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<thead>
<tr>
<th>When the independent variable changed:</th>
<th>This was the result (dependent variable):</th>
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</thead>
<tbody>
<tr>
<td>Independent Variable</td>
<td>Dependent Variable</td>
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</table>
Step 5: Results - Graphing

Title: The effect of _____________________ on ______________________.

(Independent variable)        (Dependent variable)

Create a **graph** like the one above on a separate piece of graph paper.
Step 6: Conclusion - Finding Patterns

Write out your conclusion, answering these questions:

1. What was the purpose of the experiment?

2. What were the major findings? Include data examples.

3. Was the hypothesis supported by the data?

4. How did the findings compare with other research, other scientific facts you know, or other experimentation (classmates)?

5. What possible sources of error might have occurred?

6. How could the experiment be improved, or changed for further study? (See “New Design” below)

New Design: The next thing the scientist might want to know is:

The next variable to change

The next variable to measure
Notes: Scientific Method

Name _______________________________

Date ___________ Period ______

PIGS» STEP 1: PROBLEM - this is the question you want to answer.
   Example: What fertilizer will grow a daisy plant to the tallest height?

IN» STEP 2: INFORMATION - gathering research to learn background information.
   Read and record information on such topics as plant growth, fertilizers, daisy plants.

HAWAIÎ» STEP 3: HYPOTHESIS - “educated guess.” Can be an “if..., then” statement.
   Be specific (state your best “guess” as to the answer to Step 1 question).

EAT» STEP 4: EXPERIMENT - test your hypothesis by using a step-by-step process.
   1. In your write up, explain the steps so clearly that someone could repeat your
      experiment from your directions.
   2. To design your experiment plan, set up two test groups.
      (Note: Some types of Experiments do not have a control group).

TEST GROUPS

Experimental Group (s)
This is where you introduce the one variable you are testing.
(Example: types of fertilizer put in the different pots you are testing.)

Controlled Variables
All other possible variables are kept the same. (Example:
water amount, sun, fertilizer amount, and soil are the same for each group)

Control Group
Your standard for comparison.
(example: no fertilizer added in pot).

RAW» STEP 5: RESULTS - record the facts we learned from experimenting.
   (data tables and graphs are useful)

CORN» STEP 6: CONCLUSION
A conclusion is a summary of the experiment. Someone who reads only the conclusion section of your report should be able
to completely understand your experiment. The summary should give your results, describe what those findings mean, and suggest new
questions that should be investigated. You should avoid using: “I” statements in your writing. Use phrases like “the data indicates...”. A good conclusion can be
written by answering six questions.

1. What was the purpose of the experiment?
2. What were the major findings? Include data examples.
3. Was the hypothesis supported by the data?
4. How did the findings compare with other research, other scientific facts you know, or other experimentation (classmates)?
5. What possible sources of error might have occurred?
6. How could the experiment be improved, or changed for further study?
What is a **CONTROL**?
The control in an experiment is the *standard for comparison*, in which no variable is introduced.  
*Example: No fertilizer is added to one daisy planting so you can compare the fertilized pots to this unfertilized one.  
*Note: Not every experiment has a control, many will.*

What is a **VARIABLE**?
There are actually three types: dependent, independent and controlled variables. It is important to *test only ONE variable* at a time, and to keep all other things the same (in other words, they are *controlled*).

What is the **INDEPENDENT VARIABLE**?
This is the variable you change on purpose; it is also called the manipulated variable.  
*Example: We changed the kind of fertilizer on purpose (graph on the x-axis).*

What is the **DEPENDENT VARIABLE**?
This is the variable that you measure or observe a change in as a result of changing the independent variable; also called the responding variable.  
*Example: We measure a change in height of our daisy plants (graph on the y-axis).*

What is the **HYPOTHESIS**?
This is an educated guess about how changing the independent variable will affect the dependent variable.  
*Example: If you add different types of fertilizer to daisy plants, then you will find that the Erwin Essentials Fertilizer will grow the pionsettia plant the highest, followed by Reed's Richest and Clark's Concoction.*

What is a **CONSTANT**?  
(controlled variables and constants refer to the same thing) Characteristics in an experiment that are kept unchanged in all trials.  
*Example: Amount of water, sunlight, soil types, amount of fertilizer (sometimes this is called controlling your variables).*

What are **TRIALS**?
Trials are the number of times an experiment is repeated for each level or value of the independent variable. The more trials, the more reliable the results. To be considered dependable you should do a minimum of 5 trials.  
*Example: This is one trial; do at least 4 more for valid results.*
### Data Table Self Check

- Does your table include columns and rows for all of the data you need to record?
- Did you put the independent variable in the first column and label it? Does it need to be labeled with a “unit” of some type (cm, seconds, etc.) to make it more understandable?
- Did you put the dependent variable in the second column and label it (cm, seconds, etc.)? (It could be the third, fourth, etc. column depending on how much data needs to be recorded).

*Note: When recording your data, do not put the unit labels (cm, seconds, etc.) all the way down the column. Put it in the top box of the column which indicates the same unit for all numbers in that column.

- Did you give your data table a title?

### Graphing Self Check

- Did you choose the correct type of graph? (Line graph for showing changes over time, temperature, etc. Bar graph is for comparing data that is “not connected.”)
- Did you choose a correct scale? (This means that you made the range of the data a size that will fill up most of your graph and not just a small part of it). Did you use increments (the spacing of numbers or categories on the “x” or “y” axis) that are accurate and evenly spaced?
- Is your graph neat and accurate? Are all the points plotted correctly? Did you use colors or symbols in some way if it would help your graph to be more understandable? If the data on the “x” axis would be more understandable by using a color-coded key or a key that explains the symbols used, did you include the key (also called a legend)?
- Does your graph have a title that relates to the problem that is graphed? Is it across the top of the graph? (You can always create a title by stating the “x” axis vs. the “y” axis).
- Does the “x” axis have a clear, neat label that describes units and states the independent variable? (The independent variable is the one you decide on; you change it “on purpose”).
- Is the “y” axis clearly labeled and does it describe the dependent variable? Are the units included on it, also? (The dependent variable is the one in which you “measure or observe” some change)

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**Helpful Hint on where to place variable on a graph:**

Put your left hand up, thumb out. Your fingers represent the “dependent” variable and the thumb is by itself - “independent.” Remember that you put your thumb out “on purpose” which is a hint for the independent variable.
Modified Lab Write-Up:  

Name ________________________

STEP 1 Problem (Write your problem in the form of a question.)

STEP 2 (Information “gathering” -- Think of what you can research to help you learn more about some of the things with which you are experimenting. Write two good sentences)

STEP 3 Hypothesis (Predict what you think will happen. Use an “if.....then” sentence.)

STEP 4 Experiment (Write sentences that tell how to do the experiment. You may not need all of these numbers, or you may need more.)
1.  
2.  
3.  
4.  
5.  
6.  
7.  
8.  

(continued on the next page)
**Modified Lab Write-Up (continued):**

**STEP 5 Results** (This is where you will make your data table to record your results. Also, you can put a graph of your results in this step.)

**STEP 6 Conclusion** (This is where you tell what you learned from your experiment. You should talk about the five things listed below. Use good sentences. Do not use the words “I, me, we, you” in your write-up. Use the word “the” in those places instead.)

*(Restate the problem question.)*

*(Findings - what were the results of the experiment, give data examples.)*

*(Tell if the hypothesis “was supported” or “was not” supported by the experimental results.)*

*(Error Analysis — were there some things in your experiment that might cause the data to not be completely accurate? List those things here.)*

*(Further Studies — Tell one way that you might change something in the experiment to turn it into a new experiment to do at another time.)*
Grading Checklist for Lab Write-Up:

**Step 1—Problem**
- The problem is stated in the form of a question.
- The dependent and independent variables are mentioned
- This step is specific and clear with only ONE thing being tested

**Step 2—Information “gathering”**
- Appropriate topics are researched
- Depth of research is acceptable
- Quantity of research is acceptable

**Step 3—Hypothesis**
- Clearly gives the idea of what you predict will be the answer to the Step 1 Problem question. It is in the form and an “if.....then...” statement.
- Both the dependent and independent variable are mentioned.

**Step 4—Experiment Step**
- All experiment steps and materials are clearly listed and explained. (Someone else could do this experiment from your clear directions!)

**Step 5—Results**
- A data table clearly shows your results. The data table is labeled. The independent variable is in the first column, followed by the dependent variable in the next column.
- A graph (or other visual display) of the data is included. The correct type is chosen. (A bar graph is used for comparisons; a line graph is used for “continuous data” like changes over time.)
- The graph is labeled correctly: Title, x-axis (label units too), y-axis (label units too). A bar graph may include a “key”.

**Step 6—Conclusion**
- The Step 1 Problem question is restated.
- Major findings are summarized and examples of the data are given.
- A statement about the hypothesis is made stating if it was supported or not supported?
- Possible explanations for the findings are given.
- Possible errors are explained.
- Recommendations for further experimentation are given.

**Mechanics**
- The neatness level is acceptable
- Complete sentences are used. The pronouns “I, me, my, we, you, and our” are NOT used.
- Spelling has been checked.
- QUALITY work is shown.