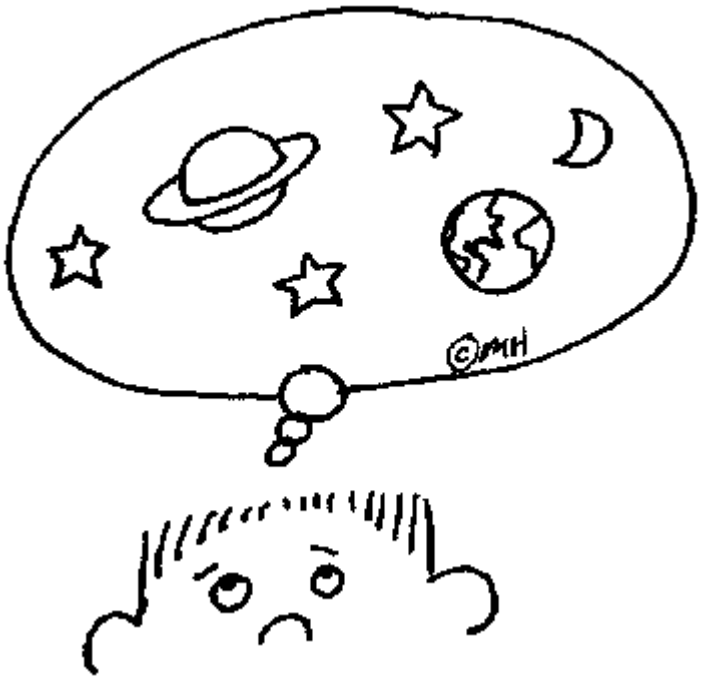
Standards-Based Instruction and Assessment Through STEM fair Projects

Student Activity Pages for Teaching STEM Fair Skills and Processes



Identifying a Good Question

For most students, the hardest part of completing a STEM fair project is selecting a good question (topic). It is important that your question be one that you are interested in and can experiment with yourself.

A good question:

- must lead to an investigation (experiment) **not** a report, a demonstration or model. The question may ask about the **effect** of one thing upon another.
- should be one from which you can collect data (ideally measurements or direct observation) **rather than** opinions.
- should be specific rather than really broad.
- is one which the materials needed to experiment with are easy to find.

Examples of good questions:
How does temperature affect the bounce of a basketball?
What type of conditions do mealworms prefer? (wet/dry, light/dark, warm/cold)
What shape of container will allow water to evaporate the quickest? (shallow/deep)

Examples of poor questions:

Question: How do volcanoes erupt?
Reason: This project would be a model not an experiment, is too vague (broad), and will not involve data collection.

Question: What are optical illusions and how do people see them?
Reason: This question is not an experiment and asks for opinions not data.

Question: What effect does caffeine have on the bloodstream?
Reason: This project is one for which students would not have the materials necessary to test it OR would involve the ingestion of caffeine to observe reactions in a vertebrate animal (including humans) and would be disqualified.

Choose which one of the two questions would make a better STEM fair project and underline it. On the line below the two questions, give a reason(s) why the one you did not choose would be a poor question for a STEM fair project. The first one is done for you.

1. Why are there craters on the moon?

   Does the drop height of an object affect the size of the crater it will make?

   The question 'Why are there craters on the moon is phrased as a report and doesn't allow for the collection of data.

2. What effect does temperature have on the growth of bean seeds?

   How do beans grow?

   _____

   _____

3. From what direction does the wind blow most frequently during one week?

   What makes the wind blow?

   _____

   _____

4. Does an apple contain water?

   How much of the weight of an apple is water?

   _____

   _____

5. Do showers or baths use more water?

   Is it better to take a shower or bath?

   _____

   _____

6. What makes a ball bounce?

   What effect does air pressure have on the bounce of a ball?

   _____

   _____

Answer Key

Choose which one of the two questions would make a better STEM fair project and circle it. On the line below the two questions, give a reason(s) why the one you did not choose would be a poor question for a STEM fair project. The first one is done for you.

1. Why are there craters on the moon?

   Does the drop height of an object affect the size of the crater it will make?

   The question 'Why are there craters on the moon?' is phrased as a report and doesn't allow for the collection of data

2. What effect does temperature have on the growth of bean seeds?

   How do beans grow?

   The question 'How do beans grow?' is phrased as a report and does not allow for the collection of data.

3. From what direction does the wind blow most frequently during one week?

   What makes the wind blow?

   The question 'What makes the wind blow?; is phrased as a report and does not allow for the collection of data.

4. Does an apple contain water?

   How much of the weight of an apple is water?

   The question 'Does an apple contain water?' is a yes or no question and does not allow for the collection of data.

5. Do showers or baths use more water?

   Is it better to take a shower or bath?
   The question 'Is it better to take a shower or a bath?' is phrased as an opinion and does not allow for the collection of data.

7. What makes a ball bounce?

   What effect does air pressure have on the bounce of a ball?

   The question 'What makes a ball bounce?' is phrased as a report and does not allow for the collection of data.

Know Your Variables

Jamal is going to complete an experiment beginning with the question and hypothesis below. Complete the activities to help him design his experiment correctly so that his results will be valid.

Question: Will a skateboard roll farther on concrete or asphalt?
Hypothesis: A skateboard will roll farther on asphalt because it is smoother.

1. What is the **independent variable** in this experiment? (What will be intentionally changed?)

_____

_____

2. What is the **dependent variable** in this experiment? (What will Jamal measure as a result of the change he made?)

_____

_____

3. Should Jamal use the same skateboard on the concrete and asphalt or a different one for the concrete and the asphalt? Why or why not?

_____

_____

4. Should Jamal just push the skateboard each time and then measure how far it goes? Why or why not?

_____

_____

5. Jamal has decided to use a ramp. He will put the skateboard at the top of the ramp and then release it. Is a ramp a good idea? Why or why not?

_____

_____

6. There are several cracks and puddles on the asphalt and concrete surfaces Jamal plans to use. Make a suggestion about what he should do when he rolls the skateboard.

7. Based on your answers to questions 3 – 6, make a list of the **variables that must be controlled** (kept the same) in Jamal's experiment.

8. Jamal plans to roll the skateboard down the ramp one time onto the concrete surface and one time onto the asphalt surface. He will measure the distance the skateboard travels on each surface and record the results on a chart. Knowing that scientists repeat their experiment in order to get valid results, explain what Jamal should do differently from what he had planned.

Challenge: On a separate piece of paper:

A. Write the steps of the procedure that Jamal must follow in his experiment. In your writing, be sure to mention the variables that must be kept controlled and how the dependent variable should be measured.
B. Design a data collection table that Jamal could use to record his results if he repeated his procedure on the concrete and on the asphalt surfaces four times each. Be sure to label all the columns and rows with headings and to include a place to record the average (mean).

Know Your Variables (Answer Key)

Jamal is going to complete an experiment beginning with the question and hypothesis below. Complete the activities to help him design his experiment correctly so that his results will be valid.

Question: Will a skateboard roll farther on concrete or asphalt?
Hypothesis: A skateboard will roll farther on asphalt because it is smoother.

1. What is the **independent variable** in this experiment? (What will be intentionally changed?)

The independent variable is the surface.

1. What is the **dependent variable** in this experiment? (What will Jamal measure as a result of the change he made?)

The dependent variable is distance the skateboard rolls.

2. Should Jamal use the same skateboard on the concrete and asphalt or a different one for the concrete and the asphalt? Why or why not?

Jamal should use the same skateboard because a different skateboard might not roll exactly the same. That is changing another variable that should be controlled.

3. Should Jamal just push the skateboard each time and then measure how far it goes? Why or why not?

Jamal would not be able to measure whether or not he pushed each time with the same amount of force. This is another uncontrolled variable.

4. Jamal has decided to use a ramp. He will put the skateboard at the top of the ramp and then release it. Is a ramp a good idea? Why or why not?

A ramp would be a good idea because Jamal would know that the skateboard would roll down the ramp the same way each trial.

5. There are several cracks and puddles on the asphalt and concrete surfaces Jamal plans to use. Make a suggestion about what he should do when he rolls the skateboard.

Jamal should find a place where the surfaces are as smooth and free of cracks as possible.

6. Based on your answers to questions 3 – 6, make a list of the **variables that must be controlled** (kept the same) in Jamal's experiment.

Same skateboard, length and height of the ramp, surfaces free of cracks and puddles.

7. Jamal plans to roll the skateboard down the ramp one time onto the concrete surface and one time onto the asphalt surface. He will measure the distance the skateboard travels on each surface and record the results on a chart. Knowing that scientists repeat their experiment in order to get valid results, explain what Jamal should do differently from what he had planned.

Jamal should do his experiment on each surface at least three times. He should then average the distances for each surface and compare the averaged data.

Challenge: On a separate piece of paper:

C. Write the steps of the procedure that Jamal must follow in his experiment. In your writing, be sure to mention the variables that must be kept controlled and how the dependent variable should be measured.
D. Design a data collection table that Jamal could use to record his results if he repeated his procedure on the concrete and on the asphalt surfaces four times each. Be sure to label all the columns and rows with headings and to include a place to record the average (mean).

Writing a Hypothesis

A hypothesis is a special kind of prediction a scientist makes about what the outcome of the experiment will be. This prediction should be based on some knowledge that the experimenter already has or some background research he or she may have done. A hypothesis/prediction is best written by thinking about the independent variable (factor that is changed on purpose in the experiment), the dependent variable (factor that is observed or measured to see what effect the change made), and making a prediction about the relationship between the two. The hypothesis should also include the reason why you think the predicted change will happen. Key words to use in a hypothesis are: **predict, because, increase, decrease, stay the same, the greatest amount, the farthest, etc.**

When students get to sixth grade, they will be expected to write their hypothesis using the **if/then** format:

If I change _____ **then** _____ will change **BECAUSE** _____.

While the students should not be held responsible for writing a hypothesis using the **If/then** format, they should be exposed to it and be allowed to use it if they choose to do so.

Example If/then Hypothesis:

If I increase the temperature of water, **then** the dissolving time of salt in water will decrease BECAUSE _____.

If I increase the height from which a drop of water is released, **then** the diameter of the splash will increase BECAUSE _____.

If I place water in containers with a greater surface area, **then** the evaporation rate of the water will increase BECAUSE _____.

Note: Students should understand that the hypothesis is a cause/effect statement. The student **causes** a change (**independent variable**). The results of the investigation (**dependent variable**) are the **effect** of that change. Your research leads you to give an explanation of **why** (because) you think this will happen.

Example:

Question:	Do different depths in a lake have different water temperatures?
Independent Variable:	Different depths of a lake
Dependent Variable:	Different water temperatures
Hypothesis:	If you go deeper into a lake, then the temperature of the water will decrease because it is further away from the sunlight.

Write a hypothesis for each of the following experiments.

1. **Question**: Does the amount of stretch of a rubber band affect the distance the rubber band will travel?
   Independent Variable: The stretch of the rubber band (will be increased)
   Dependent Variable: The distance the rubber band will travel

   Hypothesis: _____

   _____

2. **Question:** Will cups with different materials in them have different temperatures?
   Independent Variable: Cups with different materials (i.e., beans, bb's, and water)
   Dependent Variable: Temperature of the materials in the cup

   Hypothesis: _____

   _____

3. **Question:** Will the color of an insect help protect it from being eaten by a predator? (colored toothpicks will be used as model insects)
   Independent Variable: Different colored toothpicks (brown, green, yellow, blue, red)
   Dependent Variable: Number of each color of toothpick found

   Hypothesis: _____

   _____

4. **Question:** What effect does adding soap to water have on the number of drops that can be placed on a penny?
   Independent Variable: Soapy water instead of plain water
   Dependent Variable: Number of drops that stay on the penny

   Hypothesis: _____

   _____

5. **Question:** What kind of container will allow hot water to retain its heat longer?
   Independent Variable: Type of container
   Dependent Variable: Change in temperature

   Hypothesis: _____

   _____

6. **Question:** Does the length of a ramp (inclined plane) affect the amount of force needed to pull a load?
   Independent Variable: Length of ramp
   Dependent Variable: Amount of force
   Hypothesis: _____

   _____

7. **Question:** What effect do different surfaces have on how high a ball will bounce?
   Independent Variable: Different surfaces (wood, carpet, floor tiles, grass, cardboard)
   Dependent Variable: Height the ball bounces

   Hypothesis: _____

   _____

Example: ***Answer Key***

Question:	Do different depths in a lake have different water temperatures?
Independent Variable:	Different depths of a lake
Dependent Variable:	Different water temperatures
Hypothesis:	The deeper you go in a lake the temperature of the water will decrease because it is further away from the sunlight.

Write a hypothesis for each of the following experiments.

1. **Question**: Does the amount of stretch of a rubber band affect the distance the rubber band will travel?
   Independent Variable: The stretch of the rubber band (will be increased)
   Dependent Variable: The distance the rubber band will travel

Hypothesis: *I think the more I stretch the rubber band, the farther it will travel <u>because</u> stretching the rubber band gives it more energy.*

2. **Question:** Will cups with different materials in them have different temperatures?
   Independent Variable: Cups with different materials (i.e., beans, bb's, and water)
   Dependent Variable: Temperature of the materials in the cup

   Hypothesis: *I think that cups of different materials would all have the same temperature <u>because</u> they would all be in the same place.*

3. **Question:** Will the color of an insect help protect it from being eaten by a predator? (colored toothpicks will be used as model insects)
   Independent Variable: Different colored toothpicks (brown, green, yellow, blue, red)
   Dependent Variable: Number of each color of toothpick found

   Hypothesis: *I think the green insects would be protected from being eaten by predators <u>because</u> it would be harder to see in its natural environment.*

4. **Question:** What effect does adding soap to water have on the number of drops that can be placed on a penny?
   Independent Variable: Soapy water instead of plain water
   Dependent Variable: Number of drops that stay on the penny

   Hypothesis: *I think that adding soap to water would decrease the number of drops that can be placed on a penny <u>because</u> the soapy water would be slippery and would not stay on the penny.*

5. **Question:** What kind of container will allow hot water to retain its heat longer?
   Independent Variable: Type of container
   Dependent Variable: Change in temperature

   Hypothesis: *I think that a container made of plastic would allow hot water to retain its heat longer than other types of containers <u>because</u> a plastic container doesn't feel hot on the outside like glass or metal.*

6. **Question:** Does the length of a ramp (inclined plane) affect the amount of force needed to pull a load?
   Independent Variable: Length of ramp
   Dependent Variable: Amount of force
   Hypothesis: *I think the longer the ramp the larger the force needed to pull a load up the ramp <u>because</u> I know I get more tired when I climb a long hill than when I climb a smaller one.*

7. **Question:** What effect do different surfaces have on how high a ball will bounce?
   Independent Variable: Different surfaces (wood, carpet, floor tiles, grass, cardboard)
   Dependent Variable: Height the ball bounces

   Hypothesis: *I think the ball will bounce higher on the floor tiles and on other surfaces <u>because</u> floor tiles are smooth and hard and the other surfaces are less smooth or less hard.*

Writing a Procedure

Rebecca is planning to do a STEM fair project to test the following question and hypothesis. Read the procedure that she will follow in her experiment and the hypothesis she has made.

Question: What food substances will cause yeast cells to produce the greatest amount of carbon dioxide gas?
Hypothesis: Flour will cause the yeast cells to produce the greatest amount of carbon dioxide gas **because** it is used in cakes that rise partly due to carbon dioxide.
Materials:

flasks	water	honey	salt	flour
balloons	sugar	syrup	spoon	

Procedure:

1. Fill each flask with water.
2. Add some of each kind of food to the water in each flask.
3. Add some yeast to each one of the flasks.
4. Place a balloon over the top of each bottle to trap the gas.
5. Let sit for a few days somewhere in the house.
6. Use a ruler to measure the width of each balloon and record on a chart.

In designing her experiment and writing her procedure, Rebecca has forgotten some important things that scientists must do each time they experiment.

Some of the things scientists must do to design a valid experiment are …

- State the exact amount of each material they use so other scientists can repeat their experiment.
- Control all variables in the experiment (keep them the same) except the one that they are manipulating (changing).
- Repeat the experiment more than one time or use more than one test object to see if they get consistent (similar) results.

On the next page, rewrite Rebecca's list of materials and her procedure so it is a valid experiment. Think carefully about amounts (measurements) and units you will use for each listed material. Be sure the steps of the procedure reflect what variables are being controlled (kept the same) in the experiment.

Question: What food substances will cause yeast cells to produce the greatest amount of carbon dioxide gas?

Hypothesis: Flour will cause the yeast cells to produce the greatest amount of carbon dioxide gas because it is used in cakes that rise partly due to carbon dioxide.

Materials:

_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

Procedure:

Designing a Data Collection Table

Your data collection table should be designed before you begin your actual experiment. You will need the table to record data at the same time you collect it. You should try to collect data that can be measured, counted, or directly observed rather than people's opinions.

A data table should include a title that tells about the data. Tables are made up of columns that are drawn vertically (down) and rows that are drawn horizontally (across). To create a data collection table for a science experiment, you need to have spaces to record data related to the following ideas:

1. the **independent (manipulated) variable** (what you are changing);
2. the **dependent (responding) variable** (the results you will be measuring);
3. how many **tests (trials or subject)** will be conducted; and
4. the **average (mean)** of data related to the dependent variable.

Examples:
A data collection table for an experiment where a student rolls a marble down different height ramps to see how far the marble will travel might look like this:

Distance a Marble Rolls From Different Height Ramps **(Title)**

	Distance Marble Rolls **(Dependent Variable)**				
Height of the Ramp **(Independent Variable)**	**Trial 1**	**Trial 2**	**Trial 3**	**Trial 4**	**Average (Mean)**
10 cm					
20 cm					
30 cm					

A data collection table for an experiment to test how the number of drops of glycerin in a bubble solution affects the size of a bubble might look like this:

The Effect of Adding Glycerin to a Bubble Solution **(Title)**

	Number of Drops of Glycerin (**Independent Variable)**		
Size of Bubble **(Dependent Variable)**	**Two Drops**	**Four Drops**	**Six Drops**
Trial One			
Trial Two			
Trial Three			
Average (Mean)			

1. Design a data collection table in the space below that could be used to record data for an experiment to test the following question:

Question: What effect does cold have on the bounce of a ball?

Independent variable: **The ball will be tested at two temperatures—room temperature and after being in the freezer over night.**

Dependent variable: **The rebound height of the ball will be measured.**

Trials: **Three trials for each temperature of the ball.**

Average (mean): **The average of the three trials will be calculated.**

2. Design a data collection table in the space below that could be used to record data for an experiment to test the following question:

Question: Does the size of a parachute affect the amount of time it takes an object to fall 10 meters?

Independent variable: Three different size parachutes with an area of 100 sq. cm, 400 sq., and 900 sq. cm.

Dependent variable: Amount of time object takes to hit the ground.

Trials: Five trials for each size parachute.

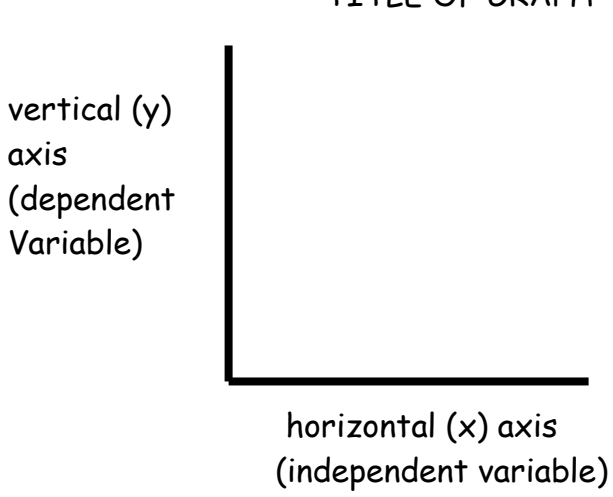
Average (Mean): The average of the five trials will be calculated.

Making a Bar Graph or a Line Graph

Bar Graph—bar graphs should be used to show data that reflect amounts (counted or measured) from separate groups. For example, the average number of bounces for different balls dropped from the same height would best be shown on a bar graph. The number of different types of birds visiting a bird feeder on the same day would also be best shown on a bar graph. The bars drawn on a bar graph must all be the same width and are separated by spaces between them.

Line Graph—line graphs are used to show relationships among data. In particular, line graphs show trends in data (increasing, decreasing, or staying the same). Experiments that are measuring time, temperature, or distance will usually produce data that should be graphed as a line graph. The amount of time a solid takes to dissolve in a different range of temperatures would be shown on a line graph. The height a ball will rebound when dropped from different heights would also be best represented on a line graph.

For both bar and line graphs in science, the independent variable is usually shown on the horizontal (x) axis of the graph and the dependent variable is shown on the vertical (y) axis.



The graph should have:

- number of scales in even intervals (1's, 2's, 5's, 10's, 20's, 100's, 1000's, etc.);
- labels for both the horizontal (x) and vertical (y) axes; and
- a title that tells what is being represented on the graph.

Activity 1

Identify whether the data collected in the experiments described below should be graphed as a bar graph or a line graph.

a. The number of paper clips each type of magnet can pick up.

_____

b. The effect different amounts of salt have on the freezing point of water.

_____

c. The type of food that mealworms prefer.

_____

d. The measurement of the amount of erosion of a hill that is rained on over a three-week period.

_____

Activity 2

Decide whether the data collected in the experiment below should be represented in the form of a bar graph or a line graph. Use the grid below to construct the type of graph you have chosen for the data.

Question: How much of the garbage thrown out in the cafeteria in one school week could be recycled?

Total Amount of Weight of Each Type of Recyclable Garbage

Type of Garbage	Paper	Plastic	Glass	Aluminum
Weight in Kilograms	65 kilograms	40 kilograms	5 kilograms	10 kilograms

Decide whether the data collected in the experiment below should be represented in the form of a bar graph or a line graph. Use the grid below to construct the type of graph you have chosen for the data.

Question: Does the amount of salt in a salt water solution affect how an egg will float in the solution?

Distance From the Bottom of the Cup in Centimeters

Amount of Salt	Trial One	Trial Two	Trial Three	Average (Mean)
No salt	0 cm	0cm	0cm	0cm
10 grams	2cm	3cm	2cm	2.5cm
20 grams	4cm	4cm	4cm	4cm
30 grams	4cm	8cm	6cm	6cm

Drawing a Conclusion

Study the question, hypothesis, and results of the experiment below. Read the conclusion that has been written for the experiment. As you read, be sure to think about the four parts that are needed in a conclusion:

1. Reflecting back on the original hypothesis and stating whether it was supported by the results of the investigation or not.
2. Answering the original question that started the investigation and including the results that were used as the basis for that answer.
3. Stating any inferences that can be made from the results of the experiment.
4. Mentioning any additional questions that could be investigated or information that could be researched in the future.

Question: Does the amount of salt added to a solution affect the boiling point temperature of the solution?

Hypothesis: As the amount of salt added to a salt solution increases, the boiling point will stay the same because I think water always boils at the same temperature.

Results:

Boiling Point Temperature Using Different Amounts of Salt

Average Temperature at Which Boiling Starts	Amount of Salt in Solution
100 degrees Celsius	No Salt
101 degrees Celsius	10 grams of salt
102 degrees Celsius	30 grams of salt
103 degrees Celsius`	50 grams of salt

Conclusion:

My hypothesis was not supported by the results of my investigation. I thought that salt would not have an effect on the boiling point temperature of the solution. In my experiment I found out that as you added more salt to the solution, the boiling point of the solution increased. The average boiling point temperature was 100 degrees Celsius when there was no salt in the solution and was 103 degrees Celsius when 50 grams of salt were added. I think salt makes the solution denser (heavier) that I now know saltwater boils at a higher temperature. Next time, I would like to find out if salt has any effect on the freezing point of water.

1. **Pretend you have completed an experiment and collected the data shown on the chart below. Use the sentence starters to write a conclusion for the experiment.**

> My hypothesis was…. (supported or not supported)
> In this experiment, I found out that….
> The results (data) showed that…..
> One thing I can infer from my experiment is….
> I would also like to find out….

Question: Does the size of a solid affect how quickly it will dissolve in water?

Hypothesis: Smaller size solids will dissolve quicker than larger size solids because they have more surface area exposed to the water.

Results:

Time to Dissolve in Minutes

Sugar size	Trial One	Trial Two	Trial Three	Trial Four	Trial Five	Average (Mean)
Whole cube	5 minutes	4 minutes	5 minutes	5 minutes	6 minutes	5 minutes
Cube in half	3 minutes	3 minutes	4 minutes	3 minutes	4 minutes	3.4 minutes
Crushed cube	1 minute	1 minute	2 minutes	2 minutes	1minute	1.4 minutes

Conclusion:

2. **Pretend you have completed an experiment and collected the data shown on the chart below. Write a conclusion for the experiment. Use the sentence starters below if necessary.**

> My hypothesis was…. (supported or not supported)
> In this experiment, I found out that….
> The results (data) showed that…..
> One thing I can infer from my experiment is….
> I would also like to find out….

Question: What kind of soil will absorb the greatest amount of water?

Hypothesis: Sandy soil will absorb the greatest amount of water because the amount of space between the grains of sand can hold a lot of water.

Results:

Amount of Water Absorbed

Type of Soil	Trial One	Trial Two	Trial Three	Average (Mean)
Potting Soil	50 ml	47 ml	52 ml	49.7 ml
Soil w/humus	63ml	68ml	63ml	64.7ml
Clay	11ml	9ml	15ml	11.7ml
Sandy Soil	22m1	25ml	23ml	23.3ml

Conclusion: