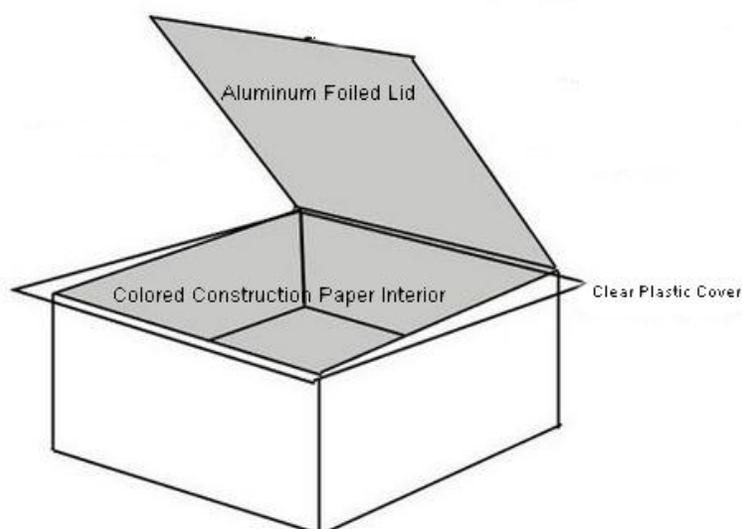


CAPT LAB ACTIVITIES OVERVIEW (STRANDS I, II, III, IV, and V)

SOLAR COOKER INVESTIGATION #1 (2008): (Strand I: Energy Transformations)

A group of students has designed a solar cooker for an investigation. They are investigating whether the material that a container is made of (plastic, glass, or ceramic) has an effect on the rate of temperature change over time. They obtain three containers of identical size. They add water to each container. The containers are placed inside the solar cooker, which is made of a box lined with aluminum foil and colored construction paper.

A Solar Cooker



A Plastic, Glass, or Ceramic Beaker With Water to be Placed in the Solar Cooker



2 Questions

- A. Identify two additional pieces of equipment that the students will need to use in their investigation.
- B. Explain why each piece of equipment is necessary.

Expected Performance: D INQ.6 Use appropriate tools and techniques to make observations and gather data.

Possible Correct Responses:

- Graduated cylinder: to accurately measure the water that must be added to the containers.
- Three identical thermometers: to be suspended in the containers so that water temperature can be measured.
- Timing device: to make sure the data for each container are collected within the same increments of time.
- Safety equipment: glove or cloth pad to handle the containers safely after heating or safety glasses to protect eyes from hot water that could splash.
- Lamp/light source/solar heat: to heat up the solar cooker.
- Meter stick: to measure the same level of water for each container.
- Other acceptable responses.

Rubric for a Score of 3

The response identifies two pieces of equipment that the students would need in order to conduct their investigation and for each piece of equipment explains why it is necessary to the investigation.

Student Responses that Received a Score of 3 for the Solar Cooker Investigation Question

First Student Response Receiving a Score of 3

Two other pieces of equipment that the students will need to use is a thermometer and a clock or stopwatch. In order to have a controlled experiment the students will need to take the temperature of the water in the containers before placing them in the solar cooker and then again after being in the solar cooker. A stopwatch or clock is necessary because the students will need to time how long the containers are in the cooker.

This response identifies two acceptable pieces of equipment that the students would need in order to conduct their investigation and explains why each piece is necessary: "thermometer...to take the temperature of the water in the containers before placing them in the solar cooker and then again after being in the solar cooker" and "a stopwatch or clock is necessary because the students will need to time how long the containers are in the cooker."

Second Student Response Receiving a Score of 3

A. A timer and a thermometer

B. A timer to keep track of how long it is being heated for. A thermometer to see the rate of temperature over time.

This response identifies two acceptable pieces of equipment that the students would need in order to conduct their investigation and explains why each piece is necessary: "timer to keep track of how long it is being cooked for" and "a thermometer to see the rate of temperature over time."

SOLAR COOKER INVESTIGATION #2 (2009): (Strand I: Energy Transformations)

A student hypothesized that container size (large, medium, and small) will affect the performance of solar cookers in heating water. The student wrote and performed the following procedure to support her claim.

Procedure:

1. Line three identical cardboard boxes with aluminum foil to use as solar cookers.
2. Place the solar cookers outside in direct sunlight.
3. Place a large glass container of water in the center of the first box.
4. Record the initial temperature of the water.
5. Allow the container to sit in the sun for 2 hours, and then check and record the final temperature of the water.
6. Place a medium-sized glass container of water in the center of the second box.
7. Repeat steps 4 and 5.
8. Place a small-sized glass container of water in the center of the last box.
9. Repeat steps 4 and 5.

The chart below shows the student's data:

Container	Temperature (°C)	
	Initial	Final
Large	39	48
Medium	39	49
Small	39	49

2 Questions

- A. Draw a conclusion regarding container size and the effectiveness of solar cookers in heating water, based on the student's results.
- B. Describe two ways the student could have improved her experimental design and/or the validity of her results.

Expected Performance: D INQ.9 Articulate conclusions and explanations based on research data, and assess results based on the design of the investigation.

Possible Correct Responses:

Conclusion:

- Container size appears to have little or no effect on the efficiency of solar cookers.
- Small or medium-sized containers heat water more than larger containers.
- The investigation was not conclusive because the student failed to take temperature readings during the two hours, and while the final temperatures were similar, one container may have heated to that temperature faster than the others.
- Other acceptable variations

NOTE: If the student takes the position that the investigation results were inconclusive, the student must explain why. No credit will be awarded for simply stating that the investigation was not conclusive.

Experimental Design Improvements:

- Clearly indicate the amount of water that was put in each container, making sure it is identical.
- Check and record the temperature at frequent and equal time increments during the investigation.
- Perform additional trials; repeat the investigation exactly.
- Add more containers of varying size to the investigation.
- Test the three solar cookers at the same time.
- Add a control (water in a container outside of the solar cookers).
- Use an artificial light source because the sun's rays vary due to clouds, etc.
- Other acceptable responses

Rubric for a Score of 3

The response provides a reasonable conclusion and describes two ways the student could have improved her experimental design.

Student Responses that Received a Score of 3 for the Solar Cooker Investigation Question

First Student Response Receiving a Score of 3

- A. The difference in the effectiveness is not much, but based on the student's results the medium and small cup were more effective.
- B. The student could have specified the number of milliliters (mL) of water to use to have a constant to make her results more precise and she could have conducted multiple trials and then averaged them.

This response provides a valid conclusion, "...the medium and small cup[s] were more effective" as well as two acceptable ways the student could have improved her experimental design and/or the validity of her results: "specify the number of mL of water to use"; "have multiple trials."

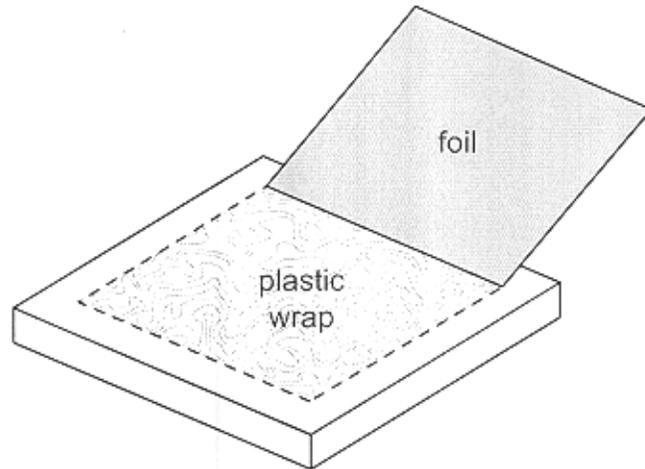
Second Student Response Receiving a Score of 3

- A. According to the student's results the medium and small containers heated the water better than the large container. The solar cooker was least effective on the large container, probably because there was more water to heat up.
- B. The student should do more trials in her experiment to ensure precision. She cannot base her conclusion on one trial. The student should also specify the size of her containers. I think if she puts all the solar cookers out in the sun at the same time, they might heat up before she uses them. She should either experiment on all the bowls (containers) at the same time or wait to put the cookers in the sun until she needs them.

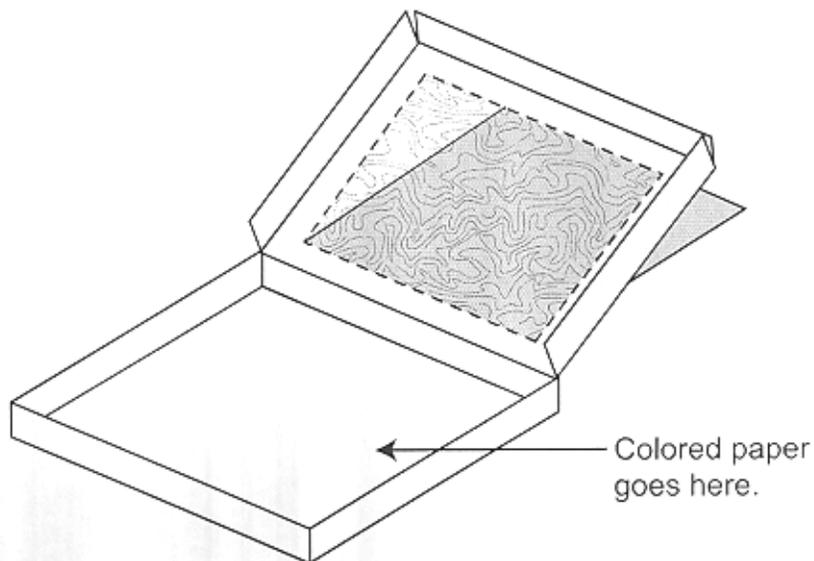
This response provides a valid conclusion: "...the medium and small containers heated the water better than the large container. The solar cooker was least effective on the large container." Two acceptable ways the student could have improved her experimental design and/or the validity of her results are given: "The student should do more trials"; "she should...experiment on all the bowls at the same time."

SOLAR COOKER INVESTIGATION #3 (2011): (Strand #1: Energy Transformations)

A group of students want to determine whether changing the color of the floor in a solar cooker will affect the rate at which food cooks. They use a pizza box to make a solar cooker. First, they cut a window in the box top, as shown below. They cover the flap with aluminum foil. The opening is covered with plastic wrap, which allows sunlight to enter the box.



Several different colors of construction paper are obtained to line the floor of the box, each color to be used in a different trial. The finished solar cooker is shown below.



3 Questions:

2. a) Explain why the flap on the top was covered with aluminum foil.
- b) Besides allowing sunlight through, what might be another purpose for covering the hole with plastic wrap?
- c) Identify the independent variable in this investigation.

Expected Performance: D INQ.6 Use appropriate tools and techniques to make observations and gather data.

Possible Correct Responses:

Sample Response:

- a)
- The flap is covered with aluminum foil to reflect* the sunlight/heat into the box and warm the food in the solar cooker.

OR

- The foil helps make the box hotter.

*unacceptable words: attract, draw, conduct, absorb, radiate

- b)
- The plastic wrap prevents the warmed air inside the box from escaping.

OR

- The plastic wrap insulates the box.

- c)
- The colors of the box floor/the construction paper sheets are the independent variable.

Rubric for a Score of 3

The response provides a valid explanation for why the flap is covered with aluminum foil, why the box opening is covered with plastic wrap, and correctly identifies the independent variable in the investigation

Student Responses that Received a Score of 3 for the Solar Cooker Investigation Question

First Student Response Receiving a Score of 3

- A. The flap on the top was covered with aluminum foil so that it could reflect any sunlight going toward it onto the plastic wrap and then the heat would cook the food. Without the foil, the pizza box flap would not have absorbed the heat.
- B. Another purpose for covering the hole with plastic wrap is to keep the heat inside the solar cooker. With nothing there, the heat energy would transfer from inside the solar cooker out to the air until both were the same temperature.
- C. The independent variable in the investigation is the color of the paper that the students put in the solar cooker.

The student provides a valid explanation for why the flap on the top was covered with aluminum foil: "...so that it could reflect any sunlight going toward it onto the plastic wrap and then the heat would cook the food." Another purpose of covering the hole with plastic wrap is correctly provided: "...to keep the heat inside the solar cooker." The independent variable is correctly identified as "the color of the paper."

Second Student Response Receiving a Score of 3

- A. The top flap was covered with foil to reflect the sunlight into the inside of the box.
- B. The plastic wrap will also trap the heat inside the box.
- C. Independent variable: The different colored papers.
Dependent variable: The rate at which the food cooks.

The student provides a valid explanation for why the flap on top was covered with aluminum foil: "...to reflect the sunlight into the inside of the box." Another purpose for covering the hole with plastic wrap is correctly provided: "The plastic wrap will also trap the heat inside the box." The independent variable is correctly identified as "the different colored papers."

POLYMER INVESTIGATION #1 (2007): (Strand II: Chemical Structures and Properties)

Students performed the following investigation.

1. Cut a piece of plastic from each of the following:
 - dry-cleaning bag
 - kitchen wrap
 - plastic sandwich bag
 - plastic grocery bag
2. Hold the sample of the dry-cleaning bag between thumb and forefinger.
3. Attach a clamp to the bottom of the sample.
4. Add weights to the clamp and measure the length the plastic stretches.
5. Repeat for other samples.
6. Record data in table.

The students recorded the following data from their investigation.

Stretching Ability Table

PLASTIC TYPE	TRIAL 1
Dry-Cleaning Bag	23 mm
Kitchen Wrap	16 mm
Sandwich Bag	14 mm
Grocery Bag	7 mm

2 Questions:

- A. After analyzing the data, the students concluded that the data supported their original hypothesis. What could have been the students' hypothesis?
- B. Support your answer with specific information from the investigation.

Expected Performance: D INQ.3 Formulate a testable hypothesis and demonstrate logical connections between the scientific concepts guiding the hypothesis and the design of the experiment.

Possible Correct Responses:

- The plastic used to make grocery bags is stronger (less likely to stretch or tear) than the other plastics: the plastic grocery bag stretched 7 mm, which was less than the other plastics.
- The plastic used to make dry cleaning bags is weaker (more likely to stretch or tear) than the other plastics: the plastic dry cleaning bag stretched 23 mm, which was more than the other plastics.
- The plastics used to make sandwich bags and grocery bags have similar strength: the amount of force required to stretch both of these plastics is similar, there was only a 2 mm difference.
- Other acceptable hypotheses.

Rubric for a Score of 3

The response provides a valid hypothesis that is supported by a description that includes specific information from the polymer investigation.

Student Responses that Received a Score of 3 for the Polymer Investigation Question

First Student Response Receiving a Score of 3

Their original hypothesis could have been that the grocery bag would stretch the least and/or that the dry-cleaning would stretch the most because this is what happened. The dry-cleaning bag stretched 23 millimeters (mm); while the grocery bag only stretched 7 mm.

This response provides a valid hypothesis, "the grocery bag would stretch the least and/or that the dry-cleaning bag would stretch the most," supported by specific information from the investigation, "the dry-cleaning bag stretched 23 mm, while the grocery bag only stretched 7 mm."

Second Student Response Receiving a Score of 3

- A. The students' hypothesis could have been that the dry-cleaning bag had the highest amount of stretchability.
- B. This is because the plastic that stretched the most was the dry-cleaning bag sample at 23 mm. If this was their hypothesis then the data does in fact support it.

This response provides a valid hypothesis, "the dry-cleaning bag had the highest amount of stretchability," and supports it with specific information from the investigation, "the plastic that stretched the most was the dry-cleaning bag sample (at 23 mm)."

POLYMER INVESTIGATION #2 (2010): (Strand II: Chemical Structures and Properties)

A manufacturer claims that its kitchen wrap will stretch twice as much as the leading competitor's plastic wrap without tearing. A group of students has gathered the following materials to test this claim.

- one sample of kitchen wrap from the manufacturer making the claim
- one sample of kitchen wrap from the leading competitor
- masking tape
- one clamp with a hook for adding weights
- several weights
- a metric ruler

The students wrote the following procedure for their investigation.

Procedure:

1. Take the sample of kitchen wrap from the manufacturer making the claim and attach one edge of the wrap to a table or desk with the masking tape (leaving the free end hanging down).
2. Attach the clamp to the free-hanging end of the kitchen wrap.
3. Add weights to the clamp.
4. Measure how much the plastic stretches.
5. Repeat steps 1- 4 for the leading competitor's kitchen wrap.

1 Question:

Describe **at least three** steps or pieces of information the students should add to the procedure to improve the design of their experiment.

Expected Performance: D INQ.4 Design and conduct appropriate types of scientific investigations to answer different questions.

Possible Correct Responses:

Conclusion:

- make sure each sample of plastic is exactly the same size
- make sure the exact same length of plastic was left free-hanging
- indicate the mass of each weight added to the clamp
- indicate how much time there was between each added weight (how long was each weight allowed to dangle before the next one was added)
- measure the plastic after each weight is added to the clamp
- indicate the total amount of weight each clamp held before the plastic samples began to tear
- apply the weights with the same amount of force
- perform multiple trials
- other acceptable responses

Rubric for a Score of 3

The response describes three steps or pieces of information the students should add to the procedure to improve the validity of the investigation.

Student Responses that Received a Score of 3 for the Polymer Investigation Question

First Student Response Receiving a Score of 3

First, the student should state in the procedure the specific mass (in grams) of the weights used, and should use all the same types of weights (same mass, shape, etc.). Second, the student should state in the procedure the original lengths of the wraps (which should both be the same length). This is another variable to be kept constant.

Third, the student should repeat all the steps multiple times to yield more trails and more data, so that the conclusion drawn will be more valid.

This response describes three valid steps or pieces of information the students should add to the procedure to improve the design of the experiment: "...the student should state in the procedure the specific mass (in grams) of the weights used, and should use all the same types of weights (same mass, shape, etc.)"; "...the student should state... the original lengths of the wraps (which should both be the same length)"; and "...the student should repeat all the steps multiple times to yield more trials and more data..."

Second Student Response Receiving a Score of 3

The students need to include the weight of each of the weights being added to the plastic wrap, because different amounts of weight would affect the experiment. The students need to include at what interval the weights are being placed on because add weights to the clamp could mean add one at a time or 10 at a time, it's not clear.

The students also need to specify when to measure the plastic wrap, because if it was measured after different amounts of weights for each brand, the results would not be accurate.

This response describes three appropriate steps or pieces of information the students should add to the procedure to improve the validity of the investigation: "The students need to include the weight of each of the weights being added to the plastic wrap..."; "The students need to include at what interval the weights are being placed on [the clamp]"; and "The students also need to specify when to measure the plastic wrap..."

POLYMER INVESTIGATION #3 (2011): (Strand II: Chemical Structures and Properties)

A student performed the following investigation to test four different polymer plastics for stretchability.

Procedure:

1. Take a sample of one type of plastic, and measure its length.
2. Tape the top edge of the plastic sample to a table so that it is hanging freely down the side of the table.
3. Attach a clamp to the bottom edge of the plastic sample.
4. Add weights to the clamp and allow them to hang for five minutes.
5. Remove the weights and clamp, and measure the length of the plastic types.
6. Repeat the procedure exactly for the remaining three plastic samples.
7. Perform a second trial (T2) exactly like the first trial (T1).

The student recorded the following data from the investigation.

Data Table

Plastic Type	Amount Stretched (mm)	
	T1	T2
A	10	12
B	22	23
C	14	13
D	20	20

2 Questions:

1. a) Draw a conclusion based on the student's data.
b) Describe two ways the student could have improved the experimental design and/or validity of the results.

Expected Performance: D INQ.7 Assess the reliability of the data that was generated in the investigation

Possible Correct Responses:

Sample Response:

Conclusions:

- Plastic sample B has more stretchability than the other polymer plastics.
- Plastic sample A has the least amount of stretchability compared to the other polymer plastics.
- Not all polymer plastics have the same stretchability.
- Different polymer plastics have different stretchability (and are therefore suited for different applications).
- A reasonable conclusion cannot be drawn due to procedural errors.
- Other reasonable conclusions

Experimental Design Improvements:

- Provide the before and after measurements for length (Did the samples all start out the same size?).
- Make sure the samples are all of the same thickness. Variations in thickness could have caused variations in stretchability.
- Perform additional trials. Some of the samples have similar stretchability (A and C, B and D). Two trials may not be enough to conclusively state that one is more stretchable than the other.
- Indicate how many weights were added to the clamps (Was it the same number for each sample?).
- Other acceptable responses

Rubric for a Score of 3

The response draws a valid conclusion supported by the student's data and describes two ways the student could have improved the experimental design and/or the validity of the results

Student Responses that Received a Score of 3 for the Polymer Investigation Questions

First Student Response Receiving a Score of 3

The data shows that Plastic B stretched the most being 22 mm T1 and 23 mm T2. The students could have made the experiment better if they did one more trial. Also, they could have been more specific in their procedure. For example they should have told you the amount of weight you add to the plastic.

The student provides an acceptable conclusion based on the data: "...plastic B stretched the most...."
Two

correct ways to improve the experimental design and/or the validity of the results are given: "...if they did one more trial..." and "...they should have told you the amount of weight you add to the plastic.

Second Student Response Receiving a Score of 3

Based on the student's data, plastic type B stretched the most, plastic type D stretched the second most, plastic type C stretched the third most, and plastic type A stretched the least. Two ways that the student could have improved the experimental design/validity of the results are having a set weight of the weights added every 5 minutes, have a set length for the plastics at the start of the test.

The student provides an acceptable conclusion based on the data: "...plastic type B stretched the most..." Two correct ways to improve the experimental design and/or validity of the results are given: "...having a set weight of the weights..." and "...have a set length for the plastics at the start of the test." Adding weights every 5 minutes is a minor error and does not affect the final score of the response

ACID RAIN INVESTIGATION (2008): (Strand III: Global Interdependence)

A group of students wrote the following procedure for their *Acid Rain Investigation*:

1. Determine the mass in grams (g) of four different samples.
2. Pour vinegar (simulated "acid rain") in each of four separate, but identical, containers.
3. Place a sample of one material into one container and label it. Repeat with remaining samples, placing a single sample into a single container.
4. After 24 hours, remove the samples from the containers and rinse each sample with distilled water.
5. Allow the samples to sit and dry for 30 minutes.
6. Determine the mass in grams (g) of each sample.

The students' data are recorded in the table below.

Sample	Starting Mass (g)	Ending Mass (g)	Difference in Mass (g)
Marble	9.8	9.4	-0.4
Limestone	10.4	9.1	-1.3
Wood	11.2	11.2	0.0
Plastic	7.2	7.1	-0.1

1 Question:

After reading the group's procedure, describe what additional information you would need in order to replicate the experiment. Make sure to include at least three pieces of information.

Expected Performance: D INQ.4 Design and conduct appropriate types of scientific investigations to answer different questions.

Possible Correct Responses:

Needed Information:

- You need to know how much vinegar was used in each container.
- You need to know what type of vinegar was used in each container.
- You need to know what materials to test.
- You need to know what size/surface area of materials should be used.
- You need to know how long each sample was rinsed in distilled water.
- You need to know what drying method to use.
- You need to know what size/type of container to use.
- Other acceptable responses.

Rubric for a Score of 3

The response describes three additional pieces of information that would be needed to accurately replicate the experiment.

Student Responses that Received a Score of 3 for the Acid Rain Investigation Question

First Student Response Receiving a Score of 3

Well, first of all if the chart was not there I would not know what the four samples were, so they should have listed that. Also, it says to put them in vinegar ("acid rain") but it does not say how much vinegar should be put in. It also says to place them in a container but it does not tell us the size of the samples.

This response describes at least three additional pieces of information that would be needed to accurately replicate the experiment: "...what the four samples were...how much vinegar should be put in...what kind of container...and the size of the samples."

Second Student Response Receiving a Score of 3

In order to replicate the experiment you would need additional information such as how much vinegar in milliliters (mL) was poured into each container. Additionally, you would need to know how large the containers were and how much and for how long the samples were rinsed with distilled water.

This response describes three additional pieces of information that would be needed to accurately replicate the experiment: "...how much vinegar was poured into each container...how large the containers were...and how long the samples were rinsed with distilled water."

ACID RAIN INVESTIGATION (2010): (Strand III: Global Interdependence)

A group of students wrote the following procedure for their acid rain investigation.

Procedure:

1. Find the mass of each of three different building materials being tested.
2. Pour 200 mL of acidified water, pH 4.5, into each of three clean containers.
3. Place each sample of building material into one of the three containers.
4. After two days, remove the samples, wash them with distilled water, and allow them to dry completely.
5. Mass each sample.

The chart below shows the students' investigation results.

MATERIAL	STARTING MASS (g)	ENDING MASS (g)	DIFFERENCE IN MASS (g)	PERCENT LOSS
Granite	6.2	6.2	0.0	0.0
Marble	8.7	8.1	0.6	6.9
Limestone	5.3	4.1	1.2	22.6

2 Questions:

- A. What was the problem the students were investigating?
- B. Describe two things the students could do to increase confidence in their results.

Expected Performance: D INQ.3 Formulate a testable hypothesis and demonstrate logical connections between the scientific concepts guiding the hypothesis and the design of the experiment.

Possible Correct Responses:

Possible Problem:

- How does acid rain affect the mass of different building materials?
- What type of building material holds up best in acid rain conditions?
- What is the best type of building material to use outdoors?
- What type of building material will degrade most quickly in acid rain conditions?
- Other reasonable questions/problems

Increase Confidence:

- perform additional trials using the same building materials
- add a control to their investigation
- perform additional trials using water with different acidities
- use samples that have the same surface area/same amount of material
- use samples that have the same starting mass
- let the samples sit in vinegar for a longer amount of time
- make sure the temperature of the solvent is held constant for each sample
- other acceptable responses

Rubric for a Score of 3

The response describes a problem that could be investigated based on the procedure and data and describes two things the students could do to increase confidence in their results.

Student Responses that Received a Score of 3 for the Acid Rain Investigation Question

First Student Response Receiving a Score of 3

- A. Which rock eroded the most when in contact with acidic water.
- B. They could repeat the experiment and they could get three samples with the same starting mass.

This response provides a valid problem that could be investigated based on the procedure and data: "Which rock eroded the most when in contact w/ acidic water." Two correct and specifically described things the students could do to increase confidence in their results are given: "They could repeat the experiment [sic] and they could get 3 samples with the same starting mass."

Second Student Response Receiving a Score of 3

- A. The problem is to see which building material loses the most mass when put into acidified water.
- B. To increase confidence in their results, the student could have done more trials and make sure that all of their materials are clean

This response provides a valid problem that could be investigated based on the procedure and data: "...to see which building material losses [sic] the most mass when put into acidified water." The response also describes two appropriate things the students could do to increase confidence in their results: "...the student could have done more trials and make sure that all of their materials are clean."

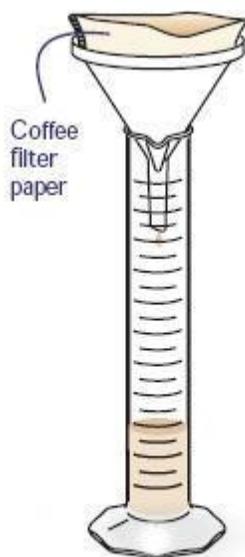
ENZYME INVESTIGATION #1 (2007): (Strand IV: Cell Chemistry and Biotechnology)

Science students conducted an investigation to determine how enzymes affect apple juice production.

Procedure:

1. Place coffee filter in paper cone; cut off 2 cm of the bottom of the cone, leaving a small hole.
2. Place 30 mL of apple sauce into measuring cup, add 5 drops of Enzyme A solution, and stir thoroughly.
3. Place a graduated cylinder under paper cone and add apple sauce to coffee filter, stirring every minute.

Device to Filter Juice (mL)



4. Measure volume of apple juice in cup after 5 minutes using a graduated cylinder.
5. Repeat steps 1- 4 for a second trial.
6. Repeat steps 1-5 using the Enzyme B solution.
7. Repeat steps 1-5 using water.

Amount of Juice Produced

Enzyme Solution	Trial 1 (mL)	Trial 2 (mL)	Average (mL)
A	14	15	14.5
B	6	5	5.5
Control = PURE WATER (H ₂ O)	5	5	5.0

2 Questions:

- A. Identify two variables that were held constant in the group's experiment.
- B. Explain why it is important for these variables to be held constant.

Expected Performance: D INQ.5 Identify independent and dependent variables, including those that are kept constant and those used as controls.

Possible Correct Responses:

- The amount of apple sauce used in measuring cup for each trial
- The number of drops of each enzyme used in each trial (volume)
- The stirring of the apple sauce (done every minute)
- The amount of time enzyme is allowed to act before measuring apple juice
- The cutting off of 2 cm of the bottom of the cone allowing the apple juice to drain

If any of these factors are not controlled, they could affect the results preventing the students from drawing a valid conclusion.

If the students were to test more than one variable at a time, they would not be able to tell which variable is responsible for the results or if it was a combination of both.

Rubric for a Score of 3

The response clearly identifies two specific variables that were held constant and provides an explanation that addresses the validity of the results in terms of testing too many variables at once.

Student Responses that Received a Score of 3 for the Enzyme Investigation Question

First Student Response Receiving a Score of 3

- A. The amount of apple sauce initially (30 mL) and the time waited (5 minutes) before measuring the volume were both held constant.
- B. It's important to hold them constant so the results do not get messed up by having more than one variable change at a time. If this happens you will not know exactly why you got the results you did and if they are accurate.

This response correctly identifies two variables that were held constant, "the amount of apple sauce" and "the time waited before measuring the volume [of juice]," and correctly explains why it is important to keep these variables constant, "...so the results don't get messed up by having more than one variable change at a time."

Second Student Response Receiving a Score of 3

- A. Two variables held constant were the amounts of apple sauce (30 mL) and the number of drops (5) of either the enzyme or water and the amount of time (5 minutes) was also constant.
- B. It is very important for these variables to be held constant because if different amounts of apple sauce or drops of enzyme were used for each trial then the results may be inaccurate. Also, if you left the apple sauce for different amounts of time then the ones there longer would make more juice.

This response correctly identifies three variables that were held constant, "...the amounts of apple sauce, the # of drops of the enzyme...and the amount of time (5 minutes.)..." and correctly explains why it is important to keep these variables constant: "if you left the apple sauce for different amounts of time, then the ones there longer would make more juice."

ENZYME INVESTIGATION #2 (2008): (Strand IV: Cell Chemistry and Biotechnology)

Science students conducted an investigation to determine how enzymes affect apple juice production.

Procedure:

1. Place coffee filter in paper cone; cut off 2 cm of the bottom of the cone, leaving a small hole.
2. Place 30 mL of apple sauce into measuring cup, add 5 drops of Enzyme A solution, and stir thoroughly.
3. Place a graduated cylinder under paper cone and add apple sauce to coffee filter, stirring every minute.
4. Measure volume of apple juice in cup after 5 minutes using graduated cylinder.
5. Repeat steps 1- 4 for a second trial.
6. Repeat steps 1-5 using the Enzyme B solution.
7. Repeat steps 1-5 using water.

Amount of Juice Produced

Enzyme Solution	Trial 1 (mL)	Trial 2 (mL)	Average (mL)
A	14	15	14.5
B	6	5	5.5
Control = PURE WATER (H ₂ O)	5	5	5.0

2 Questions:

- A. What conclusion can be drawn from the students' experiment and results?
- B. Assess the ***reliability*** of the results of this investigation.

Expected Performance: D INQ.7 Assess the reliability of the data that was generated in the investigation.

Possible Correct Responses:

Conclusions:

- Enzyme A produces the most apple juice from applesauce.
- Enzyme B is not very effective at producing apple juice from applesauce.

Reliability:

- The results are reliable because the experimental design included a variable and a control.
- The results are reliable because the experiment was repeated once and similar results were obtained.
- The results should be questioned because only two trials were performed which is not sufficient data upon which to base a sound conclusion.

Rubric for a Score of 3

The response draws a valid conclusion supported by the students' experimental results and explains why the results were or were not reliable.

Student Responses that Received a Score of 3 for the Enzyme Investigation Question

First Student Response Receiving a Score of 3

Using this data we can conclude that Enzyme Solution A was very effective at producing apple juice from apple sauce. Whereas Enzyme Solution B did nearly nothing to produce apple juice since it produced the same amount of liquid as plain old water.

This experiment was relatively reliable since they took multiple trials and had a control, but they could have improved it by measuring the volume of the liquid in the graduated cylinder several different times throughout the experiment.

This response provides a valid conclusion ("enzyme solution A was very effective at producing apple juice from apple sauce") and specifically explains why the results are reliable ("they took multiple trials and had a control").

Second Student Response Receiving a Score of 3

- A. From the students' experiment and results I can conclude that the Enzyme A Solution produces the most juice when added to apple sauce. I conclude this because Enzyme A produced an average of 14.5 mL of juice and the next highest was Enzyme B which produced an average of 5.5 mL of juice. I can also conclude that the Enzyme B Solution and water were similar because they produced a similar amount of juice when added to the apple sauce.

- B. This investigation is somewhat reliable because the constants were very clear but I could see many sources of error forming. Also, there were only 2 trials which may not be enough to draw conclusions from.

This response provides a valid conclusion ("Enzyme A solution produces the most juice when added to apple sauce"), provides a general explanation of why the results are reliable ("the constants were very clear"), and provides a general explanation of why it may not be reliable ("there were only 2 trials").

ENZYME INVESTIGATION #3 (2009): (Strand IV: Cell Chemistry and Biotechnology)

A group of students hypothesized that adding an enzyme to applesauce would produce more juice than adding an enzyme to mashed pears. The students wrote the following procedure for their investigation.

Procedure:

1. Place a coffee filter in each of two plastic funnels and place each funnel in a separate beaker.
2. Put 113 g of applesauce in one filter-covered funnel.
3. Put 113 g of peeled, mashed pears in one filter-covered funnel.
4. Add 3 drops of enzyme A to the applesauce and stir for one minute.
5. Add 3 drops of enzyme B to the mashed pears and stir for one minute.
6. Allow the fruit to sit for 10 minutes.
7. Measure and record the amount of juice contained in each beaker.
8. Repeat the procedure exactly for a second trial to verify data.

The data collected during the investigation are shown in the table below.

Type of Fruit	Juice Produced (mL)		
	Trial 1	Trial 2	Trial 3
Apple Sauce	12	11	11.5
Mashed Pears	13	12	12.5

The students claimed that their original hypothesis was correct.

2 Questions:

- A. Explain why the credibility of the students' claim should be questioned.
- B. Describe two changes that the students should make to their procedure that would allow their original hypothesis to be more accurately tested and/or would ensure the accuracy of their results.

Expected Performance: D INQ.2 Read, interpret, and examine the credibility and validity of scientific claims in different sources of information.

Possible Correct Responses:

Credibility Problem:

- The procedure allowed for more than one variable.
- The students used different enzymes in each type of fruit.
- Data doesn't support the claim.
- Other acceptable responses

Changes:

- Use the same enzyme in each type of fruit (either A or B, but not both).
- Use both enzymes on each fruit.
- Add a control to the investigation (a sample of each fruit to which no enzyme is added).
- Perform additional trials.
- Other acceptable responses

Rubric for a Score of 3

The response provides an explanation for why the credibility should be questioned and describes two changes the students could make that would allow their original hypothesis to be more accurately tested and/or would ensure the accuracy of their results.

Student Responses that Received a Score of 3 for the Enzyme Investigation Question

First Student Response Receiving a Score of 3

The students' claim does not have credibility because they test two different enzymes on different fruits. Since the type of enzyme was not kept constant the larger or smaller amount of juice produced could have been because of the enzyme type and not the fruit. Also, the data shows that their hypothesis is incorrect as mashed pears produced more juice.

To improve this experiment the students should keep constant the type of enzyme added and include more trials to increase the validity of the experiment.

This response provides an acceptable explanation as to why the credibility of the students' claim should be questioned: "they test[ed] two different enzymes on different fruits ... the data shows that their hypothesis is incorrect as mashed pears produced more juice." Both explanations are acceptable but only one of them is needed for full credit. Two correct and specifically described changes that the students should make to their procedure that would allow their original hypothesis to be more accurately tested and/or would ensure the accuracy of their results are given: "the students should keep constant the type of enzymes added and include more trials."

Second Student Response Receiving a Score of 3

- A. The credibility of the students' claim should be questioned because they hypothesized that apple sauce would produce more juice with an enzyme than mashed pears with an enzyme. But, the mashed pears produced more juice in both trials.
- B. Two changes the students should do are to first have each type of fruit to be tested for both Enzyme A and Enzyme B. That way the credibility of the experiment could not be questioned. Finally, they should have a control for each type of fruit to show the effect of the enzymes.

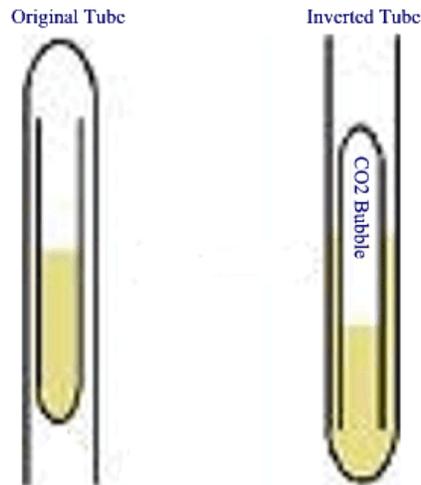
This response provides an acceptable explanation as to why the credibility of the students' claim should be questioned: "...they hypothesized that applesauce would produce more juice with an enzyme than mashed pears with an enzyme. But, the mashed pears produced more juice in both trials." Two correct and specifically described changes that the students should make to their procedure that would allow their original hypothesis to be more accurately tested and/or would ensure the accuracy of their results are given: "have each type of fruit be tested for both enzyme A and B"; "they should have a control for each type of fruit."

YEAST POPULATION DYNAMICS INVESTIGATION (2007): (Strand V: Genetics, Evolution, and Biodiversity)

A group of students wrote the following procedure for their experiment.

Procedure:

1. Place 35 mL of 25% molasses solution into three small collection tubes.
2. Place 1 mL of the yeast suspension into each collection tube.
3. Place your palm over a small collection tube and mix each suspension well.
4. Carefully slide a larger tube down over the smaller tube. Invert the tube. Repeat for each tube.



5. Measure the height of the bubbles in the smaller tubes and record.
6. Place one tube at 10°C (50°F) in a refrigerator. Leave the second one out at room temperature at 25° C (77°F). Place the third tube in a warming oven at 35° C (95°F). Make sure all tubes are in the dark and in an undisturbed location. Leave the three samples for 24 hours.
7. Measure the change in bubble size after 24 hours. Record the data.

The table below shows the results of the group's experiment.

Temperature (in °C)	Height of CO ₂ Bubble (in mm)
10	2
25	8
35	10

2 Questions:

- A. What conclusion can be drawn from the students' experiment and results?
- B. Describe two ways the students could have improved their experimental design and/or validity of their results.

Expected Performance: D INQ.9 Articulate conclusions and explanations based on research data, and assess results based on the design of the investigation.

Possible Correct Responses:

Conclusions:

- CO₂ production in yeast increases with increasing temperature.
- CO₂ production in yeast decreases with decreasing temperature.

Improvements:

- The students could repeat the experiment to verify their results or do multiple trials at each temperature and average their results.
- The students could add additional trials at higher (and/or lower) temperatures to see if the trend holds.
- The students could perform the test again at smaller temperature increments.
- The students could use a warming oven for the test tube subjected to room temperature (25° C), because in 24 hours, temperatures could fluctuate a few degrees which could affect results.
- The students should use a consistent size for the gas collection tube (not clear in procedure).
- Other acceptable responses.

Rubric for a Score of 3

The response provides a valid conclusion and describes at least two ways the students could improve their experimental design and/or the validity of their results.

Student Responses that Received a Score of 3 for the Yeast Population Dynamics Investigation Question

First Student Response Receiving a Score of 3

The conclusion can be made as the temperature increase the height of the CO₂ bubble will increase.

One way the students could have made their results more valid is by doing the experiment twice. Another way is to have another tube in an even hotter temperature.

This response provides a valid conclusion "...as the temperature increase [sic] the height of the CO₂ bubble will increase" and also provides two valid improvements "doing the experiment twice" and "have another tube in even hotter temperature."

Second Student Response Receiving a Score of 3

- A. The conclusion you can draw from this experiment is that as the temperature (°C) increases the height (mm) of the CO₂ bubbles also increases.
- B. They can repeat for 3 trials to get more valid results for each temperature. Also, instead of putting their palm over the collection tube to mix, which might have substances on it which could alter the data use a clean material to assist mixing.

This response provides a valid conclusion "...as temperature (C°) increases, the height (mm) of CO₂ Bubbles also increase" and also provides two valid improvements "...repeat for 3 trials" and "use a clean material to assist in mixing" (instead of your palm which may be contaminated).

NOTE:

All the questions, the performance expectations, possible answers, rubrics, student responses, and response overviews came from the following Connecticut State Department of Education (CSDE) website:

http://www.csde.state.ct.us/public/cedar/assessment/capt/released_items.htm