Experiment: Evaporation

Student Handouts

Evaporation 1: Starter Experiment

Getting Started

Think back to a time when you have gotten out of a swimming pool, river, or lake on a windy day.

Did your skin prickle? Did you shiver? Why does this happen?

Throughout this unit, you will investigate the science behind the culprit of your sudden chill – the process of **evaporation**.

Learning Goals

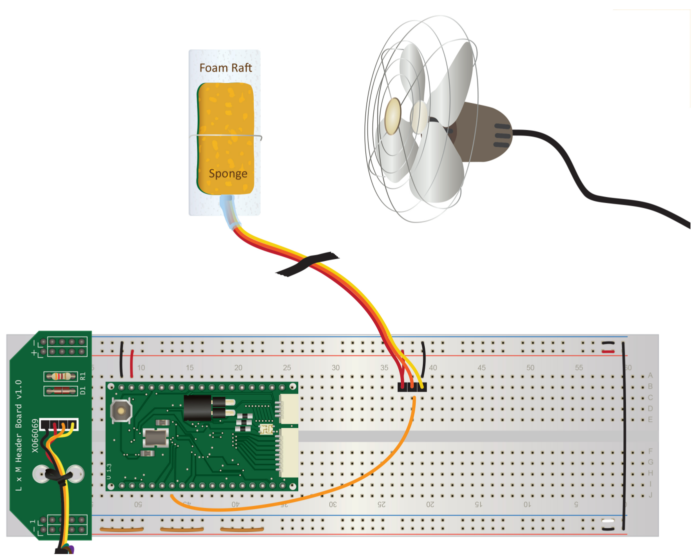
- ✓ Follow directions to assemble a simple BasicBoard system that will capture temperature changes as water evaporates from an object.
- ✓ Understand how Logo collects and displays measurements from the evaporation system.
- ✓ Describe any patterns you see in the initial data from the evaporation system.
- ✓ Describe how the different components of the evaporation system work together.

Instructions

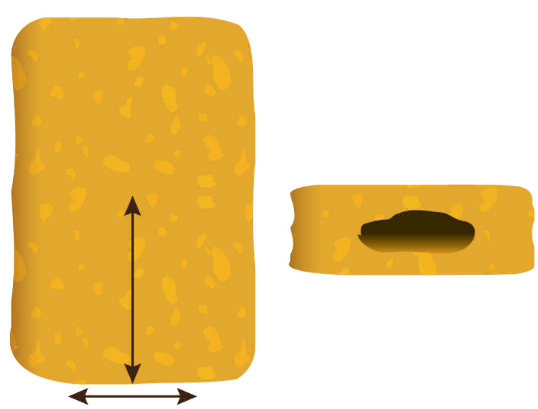
1. Gather the following materials:

- ☐ BasicBoard and HP Stream
- ☐ Wire as needed
- ☐ Leashed and wrapped temperature sensor

  (Calibration numbers must be known)
- ☐ Small sponge (sponge cut ¼ size pieces)
- ☐ Piece of foam slightly larger than the sponge
- ☐ Scissors
- ☐ Large paperclip or a piece of wire
- ☐ Fan
- ☐ Spray bottle with water



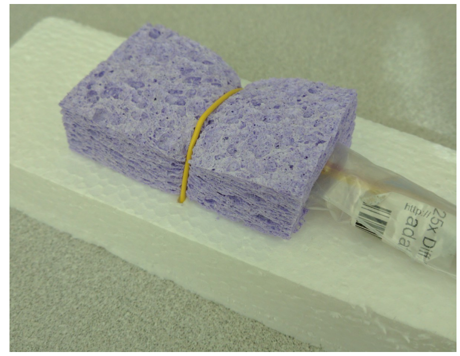
2. Create a cavity inside the sponge for the sensor. Use scissors to cut out a hole large enough to place the temperature sensor in the middle of the sponge.



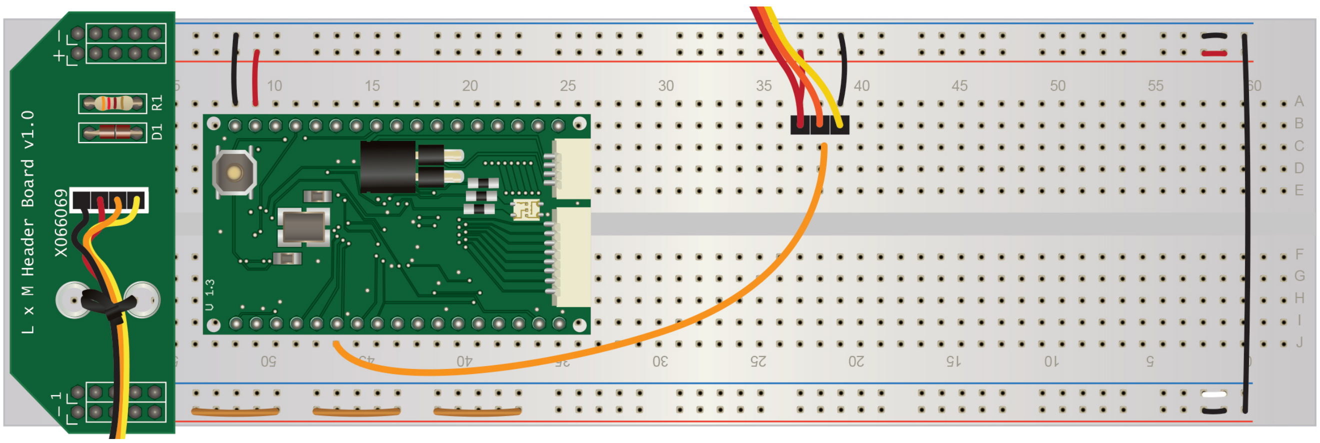
3. Insert the leashed temperature sensor. Remove additional sponge material if needed to make sure the sensor stays firmly in place.

4. Use a paperclip or length of wire to secure the sponge to a piece of foam. This foam will insulate the sponge from your table.

5. Connect the leashed temperature sensor to ADC 5 on the AppBoard.



6. Connect power and ground for the leashed temperature sensor.
   Note: if these are connected backwards, the sensor will overheat and fail.



7. Plug the FTDI cable into your HP Stream.

8. Create your own working copy of the experiment called **`Evaporation`** by following these steps. If done correctly, a new black terminal window should pop up that says **`Welcome to Logo`**.
   - Answer **`y`** to create a new experiment
   - Select **`BasicBoard.tar`**
   - Give your experiment a descriptive name. **Record this name in your notebook.**
   - Select the version **`Evaporation`**

9. Use the command **`.edit-project`** to open the `uLogo` and `jLogo` program files.

10. Open the `jLogo` file for this experiment. This file ends with the extension **`.logo`**

11. Locate the word init-calibration. Enter the calibration values **for the sensor that you are using**. Recall, the format is `[Reading1 Temperature1 Reading2 Temperature2]`

```
to init-Calibration
    make "temp1_cal [6000 4 14000 70]
end
```

12. Save the `jLogo` file.

13. Reload the experiment with the command **`.reload`**

14. Compile and download the code to the AppBoard with **`.compile`** and **`.download`**.

15. Run the program with **`.run-once`** and confirm that you see packets printed to the terminal window. A separate graph should pop up and refresh each time a new data point is added.

16. Stop the experiment with the command `..` (two dots)

17. Using a spray bottle with water, pump **5** sprays onto the sponge.

18. Turn on the fan and place it in front of the sponge.

19. Restart the program with **`.run-once`** to begin collecting evaporation data.

20. Complete the Starter Experiment challenges.

Challenges

	Credit	Task
1	◆	Draw a simple diagram of your experimental setup. Make sure to indicate the pin on the BasicBoard to which the sensor is attached. Label each component, interaction, and mechanism of this starter experiment.
2	◆	Identify the independent (manipulated) and dependent (respondent) variables in this experiment. What can be changed or controlled? What can be tested?
3	◆◆	Examine the `jLogo` and `uLogo` files for this experiment. Based on what you find in the code, explain what is being printed to the terminal window and what is being displayed on the graph.
4	◆◆	In your notebook, describe any patterns you see in the packets or the graph. How does temperature change over time? How does the rate of change vary over time?

Helpful Hints

If you need to start over, hold down the **`ctrl`** key and **`c`** at the same time. Next, type the command **`start`** and hit the **`enter`** key.
If you already created the Evaporation experiment, answer **`y`** for **`Would you like to load an existing experiment?`**
If you see **`chip not found`**, call the teacher over.
If you see ______ **`undefined`**, you are trying to run a uLogo word on the AppBoard that it doesn't understand.
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Going Further

Extra Credit	Task
◆	Recalibrate your temperature sensor. This may increase the accuracy of evaporation experiment measurements.
◆◆	Research *evaporative cooling*. Create a presentation or write a report.

Evaporation 2: Models and Questions

Getting Started

If you hang a wet towel in the sun, it eventually dries.

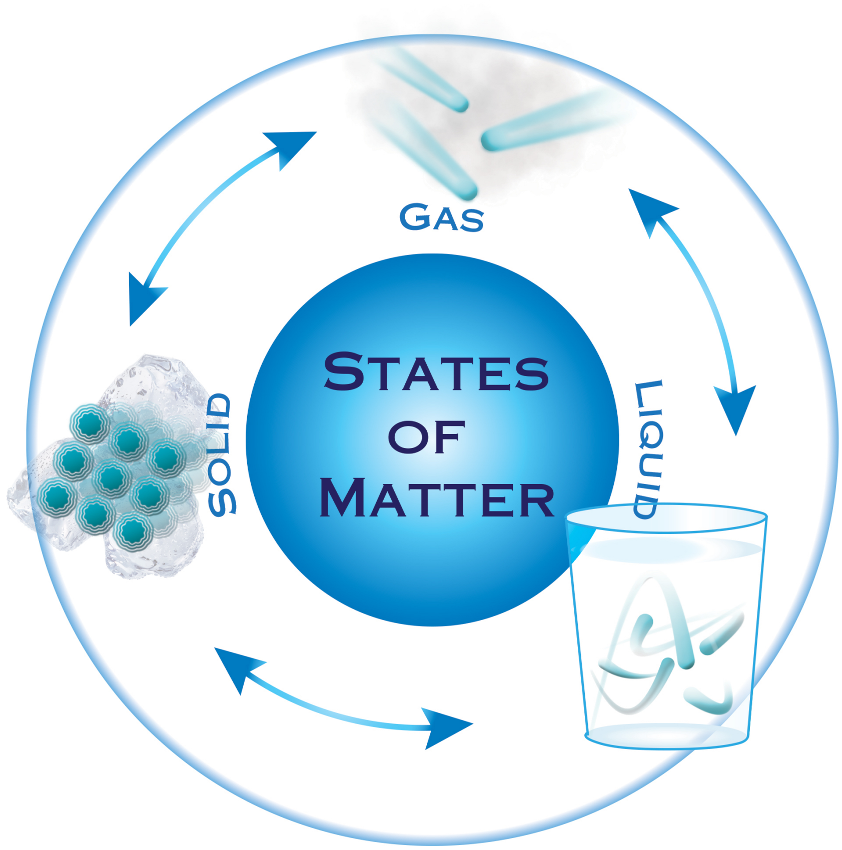
If you put a cold glass in a humid room, it will collect droplets of water.

Matter does not vanish and matter cannot suddenly reappear. Where, then, does the water go when it leaves the towel? Where does it come from when it collects on your glass?

Water is made of tiny moving particles called **molecules** - groups of atoms held together by chemical bonds. Water molecules in **solid** ice vibrate and jiggle a small amount. Water molecules in **liquid** water slip and slide around. Water molecules in **gas** vapor zoom about at high speeds and sometimes collide. The **state of matter** (solid, liquid, or gas) for water depends on the amount of **energy** there is amongst the moving molecules.

You can change water's state of matter by adding energy or by removing energy.

Add energy to liquid water and it will **evaporate** into a gas vapor.
Remove energy from gas water vapor and it will **condense** into liquid water.



Learning Goals

- ✓ Propose a model to explain how matter and energy flow at both macroscopic and microscopic levels within this evaporation system.

- ✓ Generate a testable scientific question that will refine, expand, confirm, or refute your current model of evaporation.

Instructions

1. Gather the following materials:
    - ☐ Worksheet: Experiment Plan - Models and Questions
    - ☐ Assembled evaporation experiment
    - ☐ *Optional* additional paper, whiteboard space, or poster paper

2. In the **Experiment Description** box of your Experiment Plan worksheet, write 1-2 sentences to describe the evaporation experiment.

3. In the **My Model** box, draw a model of your current understanding about the process of evaporation. Draw what you might see if you had microscopic eyes. *You may use an additional piece of paper, whiteboard, or poster paper.*

    Your model must depict the following:
    - o Experiment components (sponge, sensor, fan, etc.)
    - o How water molecules move within the system
    - o How energy flows within the system

4. In your notebook, write 3-5 sentences to describe your model.

5. Complete the Models and Questions Challenges.

Challenges

	Credit	Task
1	◆◆	• Swap your Experiment Plan worksheet with that of another group. If you drew your model on something else, attach this worksheet to your model. • Without talking to the other group, fill out the **Peer Feedback** box on their worksheet. Write at least <u>two</u> statements for each prompt. • Once you are finished, return the worksheet and model to the other group.
2	◆◆	As a group, reflect on the feedback that you received. What questions do you still have about the process of evaporation? What was unclear in your model? • In the **Scientific Question** box, write a 2-3 sentence reflection.
3	◆◆◆	The best scientific questions are driven by curiosity and the desire to know more. All scientific questions must include certain characteristics. Scientific questions are: ✓ **Answerable**. There is a real answer, often yes or no. ✓ **Testable**. You can design an experiment to find the answer. ✓ **Specific**. The question is focused and unambiguous. The question is not too broad. • As a group, generate a scientific question that will refine, expand, confirm, or refute your current model of evaporation. Write this question in the **Scientific Question** box on your worksheet. • In your notebook, write 2-5 sentences to explain how your question is answerable, testable, and specific.

Helpful Hints

Drawing a model may take many iterations. Use an erasable surface to sketch out your ideas.
Show time passing in models by using three panels: before, during, and after.
Use symbols to represent objects that are either too complicated to draw (like a circuit board) or don't have a known form (like an unknown microbe). Label or explain any symbols in your drawings. As a class, you may decide on standard symbols for certain objects.

Going Further

Extra Credit	Task
◆	Consider the following list of questions. Which of these qualify as good scientific questions? Which of these are scientific questions, but need improvement? Which of these are not scientific questions? ▪ Rank these questions from best to worst. Write 2-5 sentences explaining your ranking.
◆◆	Consider the following list of questions. Some are examples of scientific questions and some are examples of non-scientific questions. ▪ Improve the quality of two scientific questions in this list. ▪ Rewrite two non-scientific questions in this list.
◆◆	The words ***who***, ***what***, ***where***, ***when***, **why**, and ***how*** are the 6 most common ways to start a question. ▪ For each of these words, write two scientific questions. ▪ Which of these 6 words was the easiest to use in a scientific question? Which of these 6 words was the hardest to use? Write 2-5 sentences explaining your reasoning.

Example Questions

A. What is the relationship between temperature and altitude in the atmosphere?
B. Why do people get colds?
C. Who decided to remove Pluto as a planet?
D. What is the best way to cook an egg?
E. How long can people live?
F. Do people with green eyes have better vision than people with brown eyes?
G. Who is your favorite singer?
H. How long does it take to heat a liter of water from room temperature to boiling in a microwave?
I. Where is the bathroom?
J. When should you plant peppers?

Experiment Plan

Models and Questions

Experiment Description

Briefly describe the natural process that this starter experiment explores.

My Model

Propose a model to explain this process

Peer Feedback

Reviewed by:

This model shows:

I do not understand or/and have questions about:

Scientific Question

What questions do you still have about the process that you modeled?
Generate a testable scientific question.

Evaporation 3: Investigation Plan

Getting Started

Intermolecular forces are the attractive forces (pull) between different molecules within a solid, liquid, or gas. To transform from one state to another, a substance must gain enough energy to overcome the intermolecular forces of attraction between molecules.

Individual molecules in a substance gain or lose energy when the **state of matter** changes.

When molecules **gain energy** from their surroundings, they move about faster.
The substance becomes **warmer**.

When molecules **lose energy** to their surroundings, they move about slower.
The substance becomes **colder**.

How do you measure energy in your experiment?
How do you know when the liquid in your experiment has transformed into gas?

Learning Goals

- ✓ Describe what evidence is needed to answer your scientific question.
- ✓ Design an investigation and explain how this investigation will generate relevant patterns of evidence to answer the scientific question.
- ✓ After peer review of the scientific question and the investigation plan, revise the plan to increase relevance to your question and to generate data that is more accurate and more precise.

Instructions

1. Gather the following materials:
   - ☐ Worksheet: Experiment Plan – Investigation Plan
   - ☐ Assembled evaporation experiment
   - ☐ *Optional* additional paper, whiteboard space, or poster paper

2. In your notebook, write down an investigation plan.
   - Describe which variable(s) you plan to change and which variable(s) you plan to measure.
   - Decide on necessary modifications to the startup experiment. Assemble a materials list.
   - Decide on measurement and data collection methods. Does this require software changes? Does this require hardware changes?
   - Identify sources of uncertainty. How will you quantify this uncertainty?
   - Explain how you will process and analyze data.

3. Use the Experiment Plan worksheet to organize the details of your initial plan.
    - In the **Variables** box, list the variables you plan to change (independent or manipulated variables) and list the variables you plan to measure (dependent or responding variables).
    - In the **Materials** box, list all materials you will need.
    - In the **Predicted Result** box, provide an example of the evidence you expect to collect.

4. Perform a test run of your experiment. Record your observations and data in the **Initial Evidence** box.

5. Complete the Investigation Plan Challenges.

Challenges

	Credit	Task
1	◆◆	Present your experimental design and initial test data to the class. For each groups' experiment, provide feedback on the following questions: • Is the evidence gathered relevant to the question posed? • Is the evidence gathered sufficient to address the question posed? • Is the evidence gathered reliable? • Are there any gaps or weaknesses in the experimental design?
2	◆◆◆	Refine your investigation plan based on peer feedback. In the **Final Investigation Plan** box, describe your revised procedure. • Explain how your plan will improve relevance to your scientific question. • Explain how your plan will improve the reliability of your data collection. Use additional paper as needed.

Helpful Hints

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Going Further

Extra Credit	Task
◆	It is important to track how energy flows into, out of, and within a system during an investigation. Explain why it is important to keep track of energy when studying a system, using an example from your investigation.

Experiment Plan

Investigation Plan

Variables

Manipulated:

Responding:

Materials

Predicted Result

Initial Evidence

Perform a test run of your investigation. Record your observations and data.

Peer Feedback

Reviewed by:

Final Investigation Plan

Revise your initial plan. Explain how your plan will improve relevance to your scientific question. Explain how your plan will improve the reliability of your data collection.

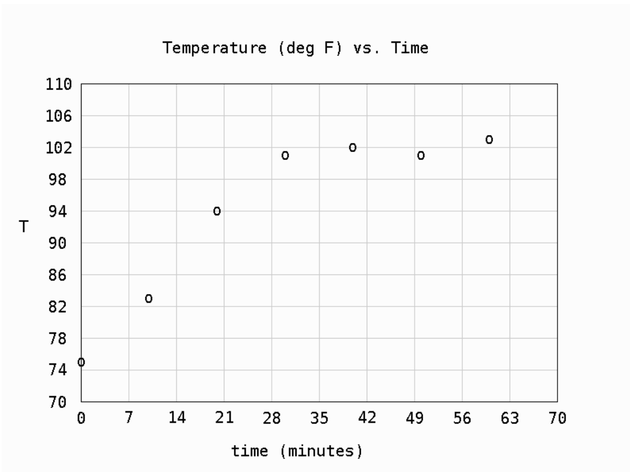
Teacher Approval:

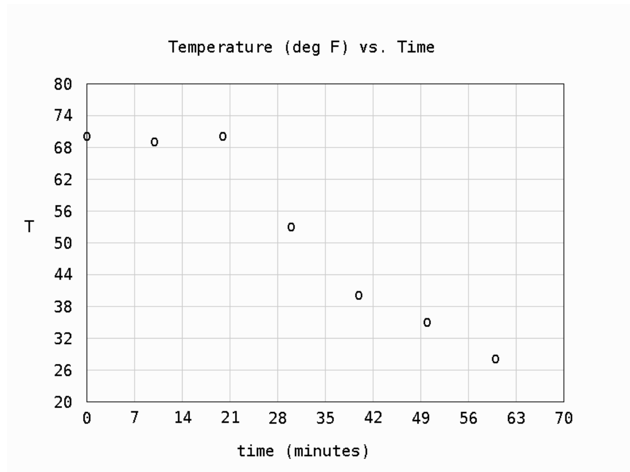
Evaporation 4: Evidence and Interpretation

Getting Started

Someone saved two graphs to the desktop of their Stream 11, but did not give them descriptive file names. How will you determine which graph corresponds to which experiment conditions?

Case A: The BasicBoard was placed under a heat lamp then removed after 5 minutes.
Case B: The BasicBoard was placed under a heat lamp.





The same student did not record observations in a laboratory notebook. Can you extract any of the following information about the experiment from these graphs? Circle yes or no for each item.

yes	**no**	Temperature of the classroom
yes	**no**	Temperature of the heat lamp
yes	**no**	Timescale of the experiment
yes	**no**	Power output of the heat lamp
yes	**no**	Precision of the temperature sensor
yes	**no**	Accuracy of the temperature sensor
yes	**no**	Distance between the heat lamp and BasicBoard
yes	**no**	When the experiment took place

Learning Goals

- ✓ Organize, represent, and analyze data from the investigation.
- ✓ Assess whether or not the data collected is sufficient evidence to answer the scientific question.
- ✓ Revise your evaporation model and explain how this new model is a better fit for available evidence.

Instructions

1. Gather the following materials:
   - ☐ Worksheet: Experiment Plan – Evidence and Interpretation
   - ☐ Assembled evaporation experiment
   - ☐ *Optional* additional paper, whiteboard space, or poster paper

2. If you have not already done so, carry out your final investigation plan.

3. If you ran your experiment during the previous class period, you can reload your data using the `jLogo` **playback** feature.

- ☐ Compile and download your code to the AppBoard
- ☐ Enter **`.run-playback`** in the terminal window instead of entering `.run-once`.

This will load all of your previously gathered data and redisplay all of your graphs.

4. Organize experimental data using tables and/or graphs. Describe any patterns or relationships that you can infer from these data.

5. Use the `jLogo` words **`x-data`**, **`y-data`**, **`analyze`**, **`quick-plot`**, and **`display-quick`** to create new graphs. Refer to Lesson 3.7 for a reminder on the function of these words.

6. Identify features of the dataset that should be analyzed in order to answer your scientific question. Use statistical analysis to identify and quantify sources of error or uncertainty.

7. Complete the Evaporation Challenges.

Challenges

	Credit	Task
1	◆	Data **tables** provide an organized way of viewing information. **Graphs** are visual representations of information from a data table. Organize data from your experiment into tables or graphs. Gather evidence by describing patterns and relationships between variables. • Fill out the **Data** box of the Experiment Plan worksheet. Include a table, graph, or written summary of your results. Recall, graphs must include the following features: ☐ A descriptive title ☐ x-axis label with units ☐ y-axis label with unites ☐ Numbered Axes ☐ Data
2	◆◆	Draw conclusions based on your gathered evidence. Is this the only way to interpret the results of your analysis? How do you know that your interpretation is appropriate? How confident are you that your group's claim is valid? • Answer your scientific question using the three parts within the **Interpretation** box. • In your notebook, write a 2-5 sentence reflection on the questions listed above

3	◆◆◆	On a piece of paper, whiteboard, or poster, draw a revised model about the process of evaporation. Your model must depict the following: • Experiment components (sponge, sensor, fan, etc.) • How water molecules move within the system • How energy flows within the system In the **Revised Model** box, briefly sketch your new model and explain why this model is a better fit for the evidence that you gathered.

Helpful Hints

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Going Further

Extra Credit	Task
◆	Scientists often have to define the boundaries of physical systems and use them to create models to test ideas. Explain why defining systems and models is important in science, using an example from your investigation.
◆◆	Do you agree with the following statements? Write a 1-2 paragraph reflection. "In science, there is no difference between data and evidence." "Observations are facts. Inferences are just guesses."

Experiment Plan

Evidence and Interpretation

Data

Organize, represent and analyze data from investigations. Describe sources of error or uncertainty.

Interpretation

Claim	Evidence	Justification
Answer your scientific question	Provide evidence to support your claim	Explain why your evidence is relevant and important

Revised Model

Revise your initial model based on these investigation results.

Evaporation 5: Presentation

Getting Started

Presentations come in many forms. Here are just a few:

Video	Diorama	Article
Poster	Song	Poem
Lecture	Book	Demonstration

Think about the best presentation you've ever seen. Think about the worst presentation you've ever seen. What is the different between them? What made the best one good? What made the worst one bad?

Learning Goals

- ✓ Create an evidence-based account of the investigation process and the answer to the scientific question.

Instructions

1. Create a group presentation for your experiment. As you write your presentation, remember to do the following:
   - State the explanation you are trying to support.
   - Include genuine evidence (data + analysis + interpretation).
   - Explain why the evidence is important and relevant.
   - Organize your argument in a way that enhances readability.
   - Use a broad range of words including vocabulary that you have learned.
   - Use proper grammar, punctuation, and spelling.

2. Complete the Presentation Challenge.

Challenges

	Credit	Task
1	◆	Present your Evaporation Experiment to the class. • Connect your HP Stream to the projector and demonstrate your final investigation to the class using the `jLogo` playback feature. • Share your presentation with the class. • Answer questions from the class about your project.

Helpful Hints

If you need to start over, hold down the **`ctrl`** key and **`c`** at the same time. Next, type the command **`start`** and hit the **`enter`** key.
Make sure your HP Stream is set to mirror your screen to the projector.
If you see **`I don't know how to ______`**, you are trying to run a jLogo word on the HP Stream that it doesn't understand.
If you get an error message, see if you can figure out what you did wrong by asking a classmate for help. If all else fails, ask your teacher.

Going Further

Extra Credit	Task
◆	Science is an ongoing process. What new questions should be investigated to build on your research? What future data should be collected to answer your questions?
◆◆	Communicating scientific results to peers is a valuable part of doing science. Scientists share results with the media, publish scientific papers, give presentations, and attend conferences. Locate a recent example of any of these items on the topic of evaporation. Write a 1-2 page summary and reflection.