



Education and Research: Testing Hypotheses

“I’m Melting, I’m Melting!”

Kristina Hayda, Cathy McBride, Patrick Murray, Stacey Sebert

Summary:

This 5E lesson on glaciers opens with a clip from Ice Age and a demonstration of glacial melt involving ice cubes on various surfaces. For the Exploration, students execute experiments to model environmental conditions on glacial melt through using flubber, concluding with a webquest to connect these concepts to glaciers and changes in climate overall. Next, students graph selected glacier data and use the Bigger Picture lesson to convert their graph into a work of art. Then, students complete a PhET simulation on glaciers, changing variables such as temperature, precipitation to see how the rate of melting might be affected. As a summative assessment, students identify glacial ice forms via the CER method.

TAGS: Glacier, graphing, simulation

Vocabulary: Glacier (valley, marine or land terminating), abrasion, till, erosion, cirque, arete, horn, ablation, moraine.

Key Concepts & Standards:

NGSS Middle School (6-8):

- MS-ESS 2-1: Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.
 - ESS2.A: Earth's Materials and Systems: All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. (MS-ESS2-1)
 - ESS2.C: The Roles of Water in Earth's Surface Processes: Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. (MS-ESS2-4)
Global movements of water and its changes in form are propelled by sunlight and gravity. (MS-ESS2-4)
 - ESS3.A: Natural Resources: Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. (MS-ESS3-1)
 - ESS3.D: Global Climate Change: Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and

- activities. (MS-ESS3-5)
- Crosscutting Relationships: Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-ESS3-1)
- Crosscutting Relationships: Energy and Matter: Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. (MS-ESS2-4)
- Crosscutting Relationships: Stability and Change: Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale. (MS-ESS2-1)

NGSS High School (9-12):

- HS-ESS3-5 Earth and Human Activity
Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.

Objectives:

- Students will be able to develop and use a model of how glaciers are affected by changing environmental conditions (temperature, snowfall, topography, etc.) through lab activities (PhET, Flubber).
- Students will be able to analyze and interpret data to explain change in area of glaciers over time.
- Students will be able to use data and evidence to identify and write an explanation of the differences between a glacier, ice sheet, and an iceberg.
- Students will be able to recognize and explain that glaciers can be found throughout the world—even at the equator.
- Students will be able to explain the relationship between Earth’s climate and ice forms.
- Students will be able to identify factors that influence the rate of glacial melt (temperature, ablation, etc.).

Materials:

Engagement Demo:

- access to a video projector (with audio & internet)
- 3 ice cubes
- plastic wrap
- soil/sand
- 3 cookie sheets
- video recording device (optional)

Flubber lab activity: <http://www.wikihow.com/Make-Flubber> (3 different ways of making)

- glue (1 cup per group)
- borax (2 tablespoons per group) or liquid cornstarch (1 cup per group)
- hot water
- food coloring
- toothpicks
- hair dryer
- sand and other sediment types
- PVC pipe (cut in half to make U-shaped foot long pieces)
- something to elevate one end of the PVC pipe
- colored pencils
- video recording device (optional)

PhET computer activity:

- Student Worksheet:
https://docs.google.com/document/d/1P-dVoDG_LjEhco7TOvwki5FurnhKy2TMWdRALT5HPys/edit
- Teacher Answer Sheet:
<https://docs.google.com/document/d/1wYFK1f5SCogcwF7IMCa-oxly0s8DtJjEU2FIFS2mBE/edit>
- Web Simulation: <https://phet.colorado.edu/en/simulation/glaciers>
 - computers equipped with java (chromebooks don't tend to work)

Resources:

- USGS Data on areas of named glaciers:
<https://www.usgs.gov/data-tools/area-named-glaciers-glacier-national-park-gnp-and-flathead-national-forest-fnf-derived>
- Where are there glaciers in the US?
<https://www.nationalparks.org/connect/blog/americas-last-remaining-glaciers>

Background Information for Teachers:

- *Centennial glacier retreat as categorical evidence of regional climate change*, Roe, et. al., Nature Geoscience, Dec 2016

Procedure:

1. **Engagement** - students' prior knowledge accessed and interest engaged in the phenomenon
 - a. "Ice Age - Scrat Starts Ice Age" clip
 - i. <https://youtu.be/L02XRHbqSE4>
 - b. Demonstration- use model to demonstrate the flow of glaciers. Have students record observations and ask questions throughout:
 - i. Cover a cookie sheet in plastic wrap. Put on a flat surface. Put an ice cube in the middle of the surface. Observe. Have a student take a video of the process in order to determine the time until the cube melts.
 - ii. Put some sand/soil on a cookie sheet, spreading it until it is as flat as possible. Cover with plastic wrap. Put on a flat surface. Put an ice cube in the middle of the surface. Observe. Have a student take a video of the process in order to determine the time until the cube melts.
 - iii. Cover a cookie sheet in plastic wrap. Put some sand/soil on top of the plastic wrap on the cookie sheet, spreading it until it is as flat as possible. Put on a flat surface. Put an ice cube in the middle of the surface. Observe. Have a student take a video of the process in order to determine the time until the cube melts.
 - c. Discussion Questions
 - i. What did the students observe?
 - ii. What questions did the students have based on their observations?
 - iii. Did the same change occur in all 3 systems? Did the change occur at the same rate?
 - iv. If there was a difference between the 3 systems, what caused it?
 - v. How does this demonstration relate to Scrat's environment in Ice Age?
2. **Exploration** - students participate in an activity that facilitates conceptual change
 - a. Flubber Lab Activity:
Student Worksheet:
<https://docs.google.com/document/d/1K0ko1OJu4H7QaKzrWW39bxOW-WPiDujCMAqBBdZ20ok/edit>
Teacher Answer Key:

<https://docs.google.com/document/d/1PopFQAmff38R44vSjwG1NpDN8EGNmleoffFxWPNTZs/edit>

- i. In groups of 2, students investigate variabilities in “glacial” conditions through developing models using Flubber.
 1. type of flubber (Borax or liquid starch or edible)
 2. slope of PVC tubing
 3. viscosity of flubber
 4. temperature
 5. type of sediment in PVC
- ii. Each pair of students is responsible for their own setup (for example, one pair could investigate the rate of flow at room temperature versus when heated).
- iii. Using toothpicks to visualize the distance that the glacier traveled, have students illustrate the change. If possible, record video or take time lapse photos of the process.
- iv. **Formative Assessment**- students illustrate the changes in their flubber and answer the accompanying questions.

b. After students have completed the lab and the accompanying formative assessment, show and discuss the following sped-up gif of flubber simulating glacial flow, composed by Dr. Ellyn Enderlin:

https://www.mbari.org/wp-content/uploads/2016/10/flubber_flow-cropped.gif

c. As a conclusion to the exploration portion, students complete the attached webquest:
Student Worksheet:

https://docs.google.com/document/d/1rHJPrrdpTzHiq-_MGPWAOogcfgKZBV9Ma-4Rq6Mx7uk/edit#

Teacher Answer Key:

https://docs.google.com/document/d/1m_R-xefud3e33oSTX_e1o6hAcpD_yVUonBlmssEWWQ/edit

3. **Explanation** - students generate an explanation of the phenomenon

- a. Use Glacier Data (Google Sheet) with Data Analysis Worksheet to generate graphs with the glacial data (area of glacier):

Student Data:

<https://docs.google.com/spreadsheets/d/1WetyCHZfkPtikr5J5kuw2HL6e8Ax05IOLyfCH3EmEi8/edit>

Student Worksheet:

https://docs.google.com/document/d/1x65XPWcLZAYwKCIBOGnnIMGDxx_s4fcUk7hllWxzFLg/edit

Teacher Answer Key:

<https://docs.google.com/spreadsheets/d/1wjQqG55ePXWXPkidIM0mFxFW2DRSMIEGPjLSDFnycQd4/edit>

- b. After students have generated their graphs, discuss the following questions as a **formative assessment**:

- i. What can we observe about the changes in glaciers over time?
- ii. How do changes vary throughout the world?
- iii. How does loss of ice affect Earth’s albedo?
- iv. What is the relationship between your graphs of glacial area and Earth’s albedo? How does this relationship impact Earth’s climate?
 1. Relate to experiences with asphalt on hot summer days vs. snow in winter, etc.

- v. **Extension**: Students can illustrate graphs using “What’s the Bigger Picture?” lesson: <http://www.mbari.org/what-is-the-bigger-picture/>

4. **Elaboration** - students' understanding of the phenomenon challenged and deepened through new experiences

- a. <https://drive.google.com/file/d/0B-fHpCFOi-l6WmtwcHIEc0l3Uzg/view?ts=59710ffb> - PhET

model Glacier Landscapes Lab from Ellyn Enderlin (student version)

i. teacher answer key:

<https://docs.google.com/document/d/1wYFK1f5SCogcwF7IMCa-oxxly0s8DtJjEU2FIFS2mBE/edit>

ii. **Formative Assessment**- Students complete a guided exploration of the simulation while filling in the accompanying worksheet.

5. **Evaluation** - students assess their understanding of the phenomenon

a. Provide students with two data sets and ask them to identify whether they are presented with two glaciers, two ice sheets, or a glacier and an ice sheet. Students should use what they have learned in the webquest/exploration to support their claims with evidence, as well as an explanation of their reasoning.

b. <https://drive.google.com/file/d/0B-fHpCFOi-I6VUZzbVlzVXoyaE0/view>

Assessment:

- **Formative assessments**—used to identify areas where students are struggling so that instructors can adjust their teaching and students can adjust their studying. The links for each are located above.
 - Webquest
 - Flubber Lab Activity Illustrations & Worksheet
 - Graphing Glacier Data & Discussion
 - PhET Model Glacier Lab Exploration Worksheet
- **Summative assessments**—occur at the end of an instructional unit or course and measure the extent to which students have achieved the desired learning outcomes.
 - <https://drive.google.com/file/d/0B-fHpCFOi-I6VUZzbVlzVXoyaE0/view>

Additional Resources:

- Polar-Ice Data Story (for further exploration and investigation with satellite imagery and data): http://mosaic.njaes.rutgers.edu/polar_ice/index-story-2.html
- Albedo Lab Activity courtesy of UMass Amherst- https://docs.google.com/document/d/1ce8rw5RH0c8J5N_4iatmA2_92rVXINr0PtKKg8QBN9M/edit
- BrainPop video on glaciers. Must have a paid subscription to use- <https://www.brainpop.com/science/earthsystem/glaciers/>
- BrainPop game about glaciers; good for elementary level students- <https://www.brainpop.com/games/mobglaciers/>
- USGS Earth Explorer - <https://earthexplorer.usgs.gov/>
- A Quick Guide to Earth Explorer for Landsat 8- <https://earthobservatory.nasa.gov/blogs/elegantfigures/2013/05/31/a-quick-guide-to-earth-explorer-for-landsat-8/>
- Glacier Landscapes Lab Part 2: Google Earth- <https://docs.google.com/document/d/134plPaWmgwTxQ90JVlp-EOrNt9AQPXwVfeff0INC7e0/edit>