Hoop House Greenhouse

Key Topics: Greenhouse, Hoop House, Greenhouse Effect, Sun, Temperature, Microclimate, Seasons, Weather, Meteorology, Thermometer
Grade Levels: K, 2-8
Inside and Outside

Lesson Overview:

In this lesson students will use thermometers to measure soil temperature and use the information to determine if the soil is warm enough to support rapid, average or minimal plant growth. Students will relate seasons and weather to changes in soil temperature, recognizing that these changes affect plant growth. Students will then learn about one structure humans developed to change their local environmental conditions to grow plants in the winter time, the greenhouse! Students will engineer their own prototypes of a greenhouse to modify soil temperature and growing conditions, monitoring their greenhouse over time.

Why would farmers want to create a blanket for their crops? What are the benefits? How does it work? Let's try it!

Activities:

Option 1 - Class Discussion and Measuring Soil Temperature (40 min.)
Option 2 - Engineering Mini Greenhouses (35 min.)

Suggested Activities & Learning Objectives by Grade:

- K: Engineering Mini Greenhouses
  - K-LS1-1 What do plants and animals need to survive?
  - K-ESS2-2/K-PS3-1 How do humans change their environment to meet their needs?
  - K-ESS3-3 How can we grow plants in cold climates?
- 2: Class Discussion and Measuring Soil Temperature, Engineering Mini Greenhouses
  - 2-LS4-1 What is habitat and how does it determine what plants can grow in it?
  - 2-LS4-1 What are the different growing requirements of different plants?
- 3: Class Discussion and Measuring Soil Temperature, Engineering Mini Greenhouses
  - 3-LS4-3 What plants thrive in a greenhouse and why?
  - 3-LS4-3 How does soil temperature affect plant growth?
  - 3-ESS2-1 How does soil temperature vary from location to location?
  - 3-ESS3-1 How can a greenhouse protect plants from extreme weather?
- 4: Class Discussion and Measuring Soil Temperature, Engineering Mini Greenhouses
  - 4-ESS3-2 How can greenhouses reduce the impacts of weather to help grow food?
- 5: Class Discussion and Measuring Soil Temperature, Engineering Mini Greenhouses
  - 5-ESS2-1 How does a greenhouse model the interactions between the Earth's geosphere, biosphere, hydrosphere and atmosphere?
  - 5-ESS3-1 How can we collect data about our environment?

- ➢ MS: Class Discussion and Measuring Soil Temperature, Engineering Mini Greenhouses
    - MS-ESS2-4 How does a greenhouse model the Earth's water cycle, driven by sun and gravity?

Essential Question(s) that Connect CCCs and SEPs:

- How can we model how the structures of a greenhouse work? (Structure and Function; Developing and Using Models)
- What variables could we change to find out how the function of the greenhouse is affected? How could we change the structure of the greenhouse to benefit plants in the summer time? (Structure and Function; Planning and Carrying out Investigations)
- What is the evidence for how the structure supports the function of the greenhouse? What are three things you can measure as evidence to see if the structure of your mini greenhouse causes a difference in plant growth? (Structure and Function; Cause and Effect; Engage in Argument from Evidence)
- How does this system work? How does this system solve a problem? (Systems; Asking Questions and Defining Problems)
- What does this cause and effect relationship of soil temperature and seed germination help to explain? Will growing seeds in a greenhouse during winter cause the desired effect of seed germination and plant survival? (Cause and Effect; Construct Explanations and Design Solutions)

Materials:

Option 1 - Class Discussion and Measuring Soil Temperature

- Pre-Made Soil Temperature Chart (see prep)
- Four-five soil thermometers
- Four-five thin wooden skewers market at 2, 4, and 6 inches
- Clipboards
- Plain white paper or 3x5 note cards (1 per group of 3-4 students)
- Pencils

Option 2 - Engineering Mini Greenhouses

- 1 bag of potting mix
- One type of seed appropriate for the season
- 12oz clear plastic cups (3 per kid)
- Tape
- Water (could be in spray bottles)
- Tape for labeling
- Marker for labeling
- Laminated copy of the Greenhouse Photo if there is not a greenhouse on campus
- Laminated copy of the Mini Greenhouse Transpiration Photo
- 1 Mini Greenhouse Observation Sheet per student (ask classroom teacher to print; there are 2 per page)

EG Team Support Needed:

- None

Prep:

This activity is designed to be done 100% outside! In the case of rain the discussions and greenhouse construction can be performed inside. Alternative options for measuring soil temperature in case of rain: have students wear rain jackets or ponchos if the rain is light, measure soil temperature in a covered area, bring containers of soil into the classroom for students to measure temperature (leave one in your house or car so the temperature is warmer).

- Review this how-to guide on making the mini greenhouses with kids for picture references: How to Make a Greenhouse Using Plastic Cups
- Ask classroom teacher to print 1 Mini Greenhouse Observation Sheet per student (there are 2 per page)
- Decide ahead of time with classroom teacher where they will keep their experiment. This could be outside of their classroom or in a safe spot in the garden. Discuss that after the experiment design and set-up, it will be the classroom's responsibility to water their cups. (Frequency of watering depends on weather. Determine this with teacher ahead of time).
- Pre-measure and mark the wooden skewers at 2, 4 and 6 inches.
- Pre-make your Soil Temperature Chart using butcher paper from the teachers lounge (view "Engage" to see full example of chart.)
- Set up an outside station for the engineering mini greenhouses portion of the activity. This could be set up many different ways, but keep efficiency in mind! An assembly line on either side of a long table works well, or if your garden has multiple picnic benches you can set up all of the supplies needed at each table.

Activity Procedure:

Engage:

Option 1 - Classroom Discussion and Measuring Soil Temperature

Begin with a classroom discussion in the seating area in your garden.

Write the following underlined questions on the board, record answers, and discuss with the class:

What is weather? Write some of their defining words on the board. One easy explanation of the difference between weather and climate is that weather is what you are wearing today (shorts, sun hat, gloves, etc.) and climate is what you have in your closet (you might have summer clothes all year round in California, or some summer and some winter clothes in a more seasonal climate).

What months are hot, cold, warm, cool, snowy, or rainy? Write the seasons on the board and record the students' answers next to the season's name. What are average temperatures in the winter, summer, fall, spring? Include example temperatures next to descriptive words for the seasons like hot, cold, warm, cool.

What seasons are best for growing plants? What does it feel like outside during those months? Explain to students that soil temperatures change in the seasons, just like air temperatures change. So when the air feels cold, the soil is cooling too. Tell students that before gardeners plant, they often measure

the temperature of their soils. Why does soil temperature matter to a gardener? What effects does soil temperature have? Soil temperature has a significant role in helping to determine the rate of plant growth, and whether a plant will even survive. (Cause and Effect; Construct Explanations and Design Solutions)

Display your Soil Temperature Chart on the board and explain it to students.

Soil Temperature Chart

Soil Temperature	Conditions during growing season
Less than 40 F	**no growth**
40 F to 65 F	**some growth**
65 F to 70 F	**fastest growth**
70 F to 85 F	**some growth**
above 85 F	**no growth**

Explore:
We are now going to measure the soil temperature in our own garden to determine if the conditions are right for seed germination.

Action:

1. Remind students what the callback will be for this activity (give me 5, silent coyote, chime, etc).
2. Divide the class into groups of three to four students. Tell them that they are going to record the temperature of the soil in different areas of the garden.
3. To keep track of the data collected, you need the students to record their measurements in a chart. Give each group a clipboard with a pencil and a piece of paper (or 3x5 note card). Guide students in creating the chart below (or a similar chart) on their pieces of paper. Explain that they will measure the soil temperature at different depths. Do they think the soil temperature will be warmer or cooler as they measure the temperature deeper into the ground?

Garden Soil Temperature				
Date:				
Location	**Depth 1**	**Temperature (°F) of Depth 1**	**Depth 2**	**Temperature (°F) of Depth 2**
Under the straw, next to the building, in the sun.	*2 inches*	*60°F*	6 inches	55°F

4. Take students to the garden and demonstrate how to measure soil temperature. First measure the air temperature. Using a thermometer, measure the air temperature at shoulder height. Measure the temperature at the surface of the ground. Is there any difference? To determine the soil temperature, use the skewer that you have marked at 2, 4 and 6 inches. Push the skewer into the ground until you reach the 2 inch mark. Remove the skewer and insert the thermometer for one minute, then remove the thermometer and quickly record the temperature. Demonstrate how to record the data on the chart. Repeat at 4 or 6 inches.
5. Ask each group of students to measure and record the soil temperature in at least three locations, at two depths (2, 4 or 6 inches) per location. Help the groups identify three distinct locations for their measurements (an example of three measurement areas might include a raised bed, in a grassy area, and under mulch).

Explain:
After the students measure the temperature in three locations, gather them together and ask each group to report their findings. Ask students to refer to the Soil Temperature Chart to determine if the soil temperatures are good for planting. As the students most likely discovered, the soil temperatures change with soil depth.


Comprehension Check

Ask students to raise their hands to share:

Ask students to compare the temperatures they recorded at different depths. At which depth is the soil the warmest? Which is the coolest? Guide students in subtracting the coolest temperature from the warmest temperature to determine the difference (in degrees).

How does the sun affect soil temperature? Did any groups measure soil temperatures in an area that gets full sun and an area that is in full shade? What does your data tell us? How can we maximize the energy from the sun during a colder season?

Elaborate:
Option 2 - Building Mini Greenhouses

Students will make mini greenhouses to test the effect greenhouses have on plant growth. Follow this link for a visual guide on How to Make a Greenhouse Using Plastic Cups

Action:

1. If applicable, visit a greenhouse in the garden. If a greenhouse is not present, bring this laminated photo with you to provide a visual explanation: Greenhouse Photo. A Greenhouse is a house for plants. Why do humans live inside of houses (*shelter, warmth, protection.)* Have students step inside of the greenhouse to feel the temperature inside. Knowing what you know about soil temperature and growing conditions, do you have any evidence right now that a greenhouse structure could cause a difference in plant growth? How do you feel inside of this greenhouse? (Structure and Function; Cause and Effect; Engage in Argument from Evidence) (*Warm! My evidence is the temperature I feel on my skin. It is warmer inside of the greenhouse than outside.)* What season would it be advantageous to grow a plant inside of this greenhouse? *(Winter! The greenhouse keeps the soil temperature within a range that seeds can sprout)* How does this greenhouse system work? (Systems; Asking Questions and Defining Problems) Discuss the structure and functions of a greenhouse (*Sun light enters the greenhouse through the glass panels / plastic fabric and is converted to heat energy inside. The air inside the greenhouse can't escape and is hotter than air outside of the box*.) How could we change the structure of the greenhouse to benefit plants in the summertime? (*The summertime is hot! We could use a shade cloth material instead of clear plastic or glass to provide shade for our plants.)* What other variables could we change to find out how the function of the greenhouse is affected? (*We could leave the doors open, close the doors, build and utilize shelves, add a fan, etc.)* (Structure and Function; Planning and Carrying out Investigations)
2. Today, we'll be experimenting to see if a greenhouse has an effect on plant growth. You'll each be engineering a mini greenhouse out of two plastic cups, tape, soil, seeds, and water. (Display the laminated photo example). If we want to see if these greenhouses help plants grow, what else do we need in our experiment? (*A control to compare against.)* Our control will be one plastic cup, soil, seeds, and water. What else should we keep the same between our control and our greenhouse? (*soil height, seed type and number we plant.)* Great! Lastly, what should we be observing to see if the mini greenhouses do cause a difference in growth? What about soil temperature? (Students should observe: soil temperature and plant height, and can also observe days till sprouting, color, amount of water needed, etc.) (Structure and Function; Developing and Using Models; Planning and Carrying out Investigations)
3. Invite students over to your mini greenhouse assembly station. Demonstrate fully how to assemble both the mini greenhouse and control cup. Make sure students label their greenhouses and controls!
4. Have students place their experiments in the designated spot you discussed with their teacher. Guide students to set up both their mini greenhouses and controls in a similar environment (not one cup in full sun and one cup in full shade).
5. Demonstrate how to properly water the experiment for consistency and success. Misting with a spray bottle is recommended until the soil is moist throughout. Because the cups will not have drainage holes avoid overwatering and discuss how to properly water with the students. Remind class that it is their responsibility to water their experiments!
6. Review: What are three things you can measure as evidence to see if the structure of your mini greenhouse causes a difference in plant growth? (Structure and Function; Cause and Effect; Engage in Argument from Evidence) Have their teacher provide them with the Mini Greenhouse Observation Sheets and ask students make weekly observations for one month.

Evaluation:

Show students the laminated copy of the Mini Greenhouse Transpiration Photo. What do you notice? Why do humans sweat? Why do plants sweat?

Describe transpiration and draw on your graphic organizer as needed to help explain: Plants recycle water back into the atmosphere through a process called transpiration. Transpiration is a plant's way of sweating, releasing excess water into the air through its leaves. Water enters through the roots, carrying air and nutrients, and is pulled through the plant continuously in columns, like a straw! The excess water is released into the atmosphere through tiny openings in the leaves called stomata. You can think of these as the pores on your skin. This water is evaporated from the leaves by the heat of the sun, pulling more water up through the plant to take its place. The constant flow of water through the plant gives it shape and life! In summary, plants recycle a lot of water into the atmosphere when the sun evaporates water from the leaves, which in turn creates a vacuum in the leaves that pulls water up from the roots.

Ask students to raise their hands to share:

Where is the water in this picture? (*It has condensed onto the walls of the "greenhouse".)* How is this sweat important to the plant? (*It pulls more water through the plant.*) Where does this water go in the greenhouse? Does it escape? (*No, it cycles back into the soil for the roots to suck up.*) Do plants in a greenhouse require more or less water? (*Using greenhouses reduces our impact on the local environment through conserving water*.) (Systems; Asking Questions and Defining Problems)

Extension Activities:

- Build a hoop house greenhouse in the garden with students. Do we get the same results from this large greenhouse as in our mini greenhouse experiment?
- Turn the hoop house into a shade house in the late spring for summer and early fall!

Tips and Caveats:

Adaptations for K-2 & MS

Use less academically rigorous dialogue, especially for kindergarten.

Instead of using thermometers, have your kindergarten students use ice cubes! They can place 2-3 ice cubes on soil in different areas of the garden at the same time and watch which one melts the fastest / slowest. If a greenhouse exists, have each group put one of their icecubes inside for a comparison.

K-2 will still create mini greenhouses and controls, but guide them through the experiment design and process.

For middle school, focus on observing and modeling water cycles in soil and variations of soil temperature in different seasons and how they can use engineering to impact the natural system positively to benefit humans.

- This lesson can be done at different times of year--in some climates soil temperature will vary most in the fall and spring when day and night temperatures are most different

Cited Curriculum:

- Growing-Minds Farm to School Program: Soil Temperature
- LifeLab - The Growing Classroom: Plant Sweat
- Outside the Box Homeschoolers: How to Make a Greenhouse Using Plastic Cups