Temperature Experiment
Surface vs Air Temperature

Objectives:
Students will be able to:

- design and conduct an experiment to determine if microclimates exist in their school yard or study area.
- identify the main components of a scientific experiment.
- use standard and IR thermometers to measure surface and air temperatures.
- compare surface and air temperatures of various locations/objects in the environment.

Author:
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Time:
50 min. class period

Grade Level:
6-9

Standards
AZ Science Strands
Inquiry, Nature of Science, Personal Perspectives, Life Science, Physical Science

NGSS Core Ideas
Earth materials and systems; Conservation of energy and energy transfer

NGSS Practices
Investigations, and more

Specific AZ, Common Core, and NGSS standards on page 3.

Background:
As Phoenix has grown, the natural environment has been transformed from the native desert vegetation into a diverse assemblage of built materials, from buildings, to parking lots, to roadways. Concrete and asphalt increase mass density and heat-storage capacity. This in turn means that heat collected during the day is slowly radiated back into the environment at night. While both the city and the Sonoran Desert are hot during the day, the desert cools down much more quickly at night than the city. Scientists call this phenomenon the Urban Heat Island (UHI). Different materials found in cities absorb and retain thermal energy (heat) differently, thus the design of city landscapes can lead to different microclimates. Some of these microclimates might be cooler and some might be hotter during the day and at night.

Vocabulary:
temperature - a measure of average heat or thermal energy

microclimate - climate of a small, specific place within an area as contrasted with the climate of the entire area.

Urban Heat Island - a metropolitan area which is significantly warmer than its surrounding rural areas, a night time phenomenon of increased temperatures in the Phoenix Metropolitan area.

thermometer - instrument to measure temperature.

infrared thermometer - instrument to measure surface temperatures using infrared radiation (heat).

prediction -the expected result of a scientific test

independent variable - the factor of interest in a scientific study; the variable that is changed in an experiment

dependent variable - the factor that is measured in a scientific study;

replication - multiple measurements of the independent variable; it increases the sample size in a scientific study to account for the variation in nature and any experimental errors

data - the measurements collected by a scientist in a study; the dependent variables

results - a summary of the data collected in a study

Advanced Preparation:
For background and to generate photos for this activity, you may wish to first conduct the Natural and Built lesson.

Survey the school yard or study area for safety issues and to familiarize yourself with the variety of surfaces available to measure.

Materials:

- thermometers (2 per group)
- 1 meter dowels (1 per group)
- tape
- clip boards (1 per student)
- color wheels (1 per group)
- duct tape or material to shade the thermometer's bulb
- Student Worksheets: Designing a Temperature Investigation p. 1-4

Recommended Procedure:

Engagement:

1) Solicit ideas from students about temperature in their schoolyard. Could there be different microclimates in the schoolyard? Ask students what they know about temperature of various surfaces. Guide them to consider the differences between surface and air temperatures. Set the context for the experimental questions by introducing or reviewing the concepts of natural and built structures, microclimate and the Urban Heat Island

2) Ask students, what is the first step to conducting a scientific experiment? Identifying a question to test based on background knowledge. Introduce the following scientific questions:

- Do different surfaces have different temperatures?
- Are there temperature differences between the surface and the air above the surface (for example where your feet are vs. your face)?
- Does the type of surface affect how different the temperatures are?

3) Assign students to groups of 3 or 4. Explain that each group will be designing their own experiment to test the scientific questions.

4) Handout the Student Worksheets: Designing a Temperature Investigation p 1-4.

5) Guide students to discuss and list appropriate surfaces they might measure. Explain that this is the independent variable in the experiment that will change across measurements.

6) Discuss materials available and expectations. Student groups will measure each object at the surface and 1 meter above it three times. Ask students why replication is important. Discuss with them the possible pitfalls of sampling only one time. With more replications of the measurements, we can be more certain that our data apply broadly, not just to an isolated, special case.

Exploration:

7) Experiment Design: Ask students why is it important that different researchers use the same methods? Remind students that standardized procedures allow them to compare and pool their data. Remind students that scientific procedures must be detailed and clear so anyone could verify their results by repeating the experiment.

8) Assist student groups to complete page one of the student worksheet including the variables they will hold constant.

9) Ask students, what is the next step in the experimental process? Why is it necessary to make predictions? Predictions are necessary in science because they help us imagine possible explanations for our questions and help us ensure our experimental design is appropriate to test our questions.

10) Conduct the experiment. Students should collect data in the table on their worksheet.

Expansion:

11) Analyze data: Assist students to complete the reflection questions at the end of the worksheet based on their results.

12) Group Share: Return to the original questions and evaluate if the data answered the questions. Ask students what conclusions can be drawn from the results.

13) Discuss the following questions:

-Are there different microclimates in your school yard?

-What are some reasons that surfaces have different temperatures?

-Why is this experiment important?

-How might different temperatures affect plants, animals, and people?

Evaluation:

Students will design and conduct the experiment and complete worksheets.

Extensions:
Student groups may average the three values for each surface type. Ask students to evaluate their methods. Are the three values very different, why might that be? Why is an average important. Have students make a bar graph with surface type on the x axis and average surface temperatures on the y axis.

Journal Prompt:
Weather stations used by scientists place the thermometer in the shade and 1.3 meters (4.4 ft) above the ground, based on your observations and experiment why would this be important?

Standards

Arizona Science Standards
S1-C1-GR5-8-PO1,PO2
S1-C1-GRHS-PO2,PO4
S1-C2-GR5-HS-PO1
S1-C2-GR5-8-PO2
S1-C2-GR5-PO3
S1-C2-GR5-8-PO4,PO5
S1-C2-GRHS-PO3,PO4,PO5
S1-C3-GR5-8-PO1,PO2,PO3
S1-C3-GR7-8-PO5
S1-C3-GRHS-PO2
S1-C4-GR5-PO1
S1-C4-GR8-PO1
S1-C4-GR6-8-PO4
S1-C4-GRHS-PO1,PO3,PO4
S2-C2-GR6-7-PO3
S2-C2-GR8-PO1
S3-C1-GR5-PO1
S3-C1-GR7-8-PO1
S3-C4-GRHS-PO1,PO2,PO3,PO4
S4-C3-GR6-PO2
S4-C3-GR7-PO3,PO5
S4-C3-GRHS-PO2
S4-C4-GR8-PO1,PO2
S4-C4-GRHS-PO3,PO4
S6-C2-GR6-PO4

NGSS Core Ideas
ESS2.A: Earth materials and systems
PS3.B: Conservation of energy and energy transfer

NGSS Practices
Asking questions
Planning and carrying out investigations
Analyzing and interpreting data
Constructing explanations
Engaging in argument from evidence
Obtaining, evaluating, and communicating information

NGSS Crosscutting Concepts
Patterns
Scale, proportion and quantity
Systems and system models
Energy and matter; Flows, cycles, and conservation
Stability and Change

Common Core/ELA Literacy
RST7: Integrate content from diverse formats
WHTS1: Write to support claims
SL1: Participate in collaborations and conversations

Common Core/Mathematics
Domains:
Number and Quantity
Measurement and Data
Math Practices:
4. Model with mathematics.
2. Reason abstractly and quantitatively.

Student Worksheet (#1)
Designing a Temperature Investigation

Scientific Research Questions

- Do different surfaces have different temperatures?
- Are there temperature differences between the surface and the air above the surface (for example where your feet are vs. your face)?
- Does the type of surface affect how different the temperatures are?

How will you design an experiment to investigate these questions?

First, list the types of surfaces that you wish to investigate. (This is your independent variable that you will vary in the experiment).

Equipment

outdoor thermometer, infrared thermometer, three-foot dowel, clipboard, duct tape (material to shade the outdoor thermometer's bulb)

Plan Your Procedure

We suggest that you take three sets of measurements for the surface and air temperatures at each of your selected surfaces. This is a technique that scientists and engineers use to make sure that their measurements are accurate.

Create a plan for how you will keep the following variables constant for each surface:

Time between temperature measurements for a particular surface (note: the time between measurements should be kept consistent)

_____
_____
_____

Location(shaded, not shaded, etc.)

_____
_____
_____

Height above the surface

_____
_____
_____

Note that is it important that you sued the appropriate measurement devices. Use the infrared thermometer to measure the surface temperature and use the outside thermometer to measure the air temperature above the surface

Student Worksheet (#2)
Designing a Temperature Investigation

Design Your Experiment

Now that you know which variable you want to test, you need to determine how you will perform the experiment. Write down step-by-step what you will do and how you will collect data. **Someone who is not in your group should be able to follow your design exactly the way you would. Carefully provide details.**

Student Worksheet (#3)
Designing a Temperature Investigation

Make A Prediction

Before you start your experiment you should predict what you expect to find after you have collected the data. What impact do you think the type of surface will have on the surface and air temperatures? Why?

_____
_____
_____
_____

Collect Data Time 1 Time 2 Time 3

Surface type	Surface temp.	Air temp.	Surface temp.	Air temp.	Surface temp.	Air temp.

Student Worksheet (#4)
Designing a Temperature Investigation

Analyze Your Data

Answer the following questions and speculate about the possible explanations for your data.

1. Which surface had the greatest difference between the surface and air temperatures? Why?

_____
_____
_____
_____
_____

2. Which surface had the least difference between the surface and air temperatures? Why?

_____
_____
_____
_____
_____
_____
_____

3. If you had the opportunity to decide what type of surface you would have around your schoolyard, which would you choose? Based on data from your experiment, rank order the surfaces and explain your reasoning.

Rank order (#1 is your first choice)	Surface	Reason for rank
1		
2		
3		
4		
5		

Student Worksheet (#5)
Designing a Temperature Investigation

Journal Prompt

Weather stations used by scientists place the thermometer in the shade and 1.3 meters (4.4 ft) above the ground, based on your observations and experiment why would this be important?