FACILITATOR GUIDE

CYE

Capturing Your Environment Framework

Exploring Microclimates Using Infrared Thermometers and Kestrel Weather Stations

Extension
UNIVERSITY OF WISCONSIN–MADISON

Contents

Background

Digital Observation Technology Skills (DOTS)

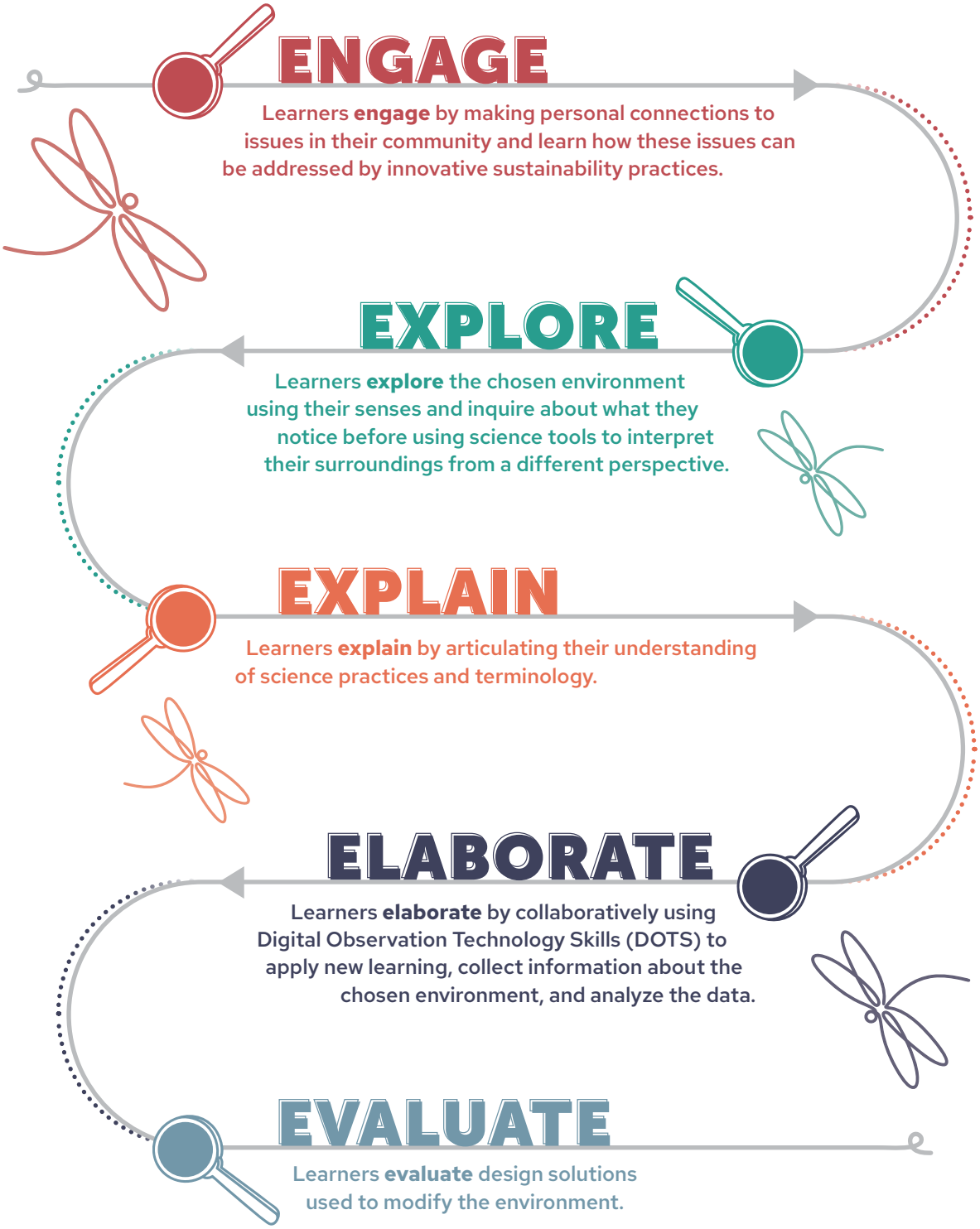
Using technology has the potential to deepen learning for all ages. As skills increase with technology use, learners can explore their environment in a new way. Technology can also give learners access to information about their environment. Learners can use digital tools to gather observation data beyond their five senses.

Introducing DOTS in learning settings is an effective way to improve learning outcomes. DOTS uses technology that allows learners to observe the natural world. DOTS uses a toolkit that includes digital mobile technology devices. The tools in the kit can range from digital microscopes and weather meters to other tools that support data collection. The DOTS tools are chosen based on utility, cost, ease of use, and the ability to collect clear and useful data. Mobile technology, such as tablets or cell phones, may be a distraction when used outdoors. However, using technology that prioritizes a task-oriented experience with a distinct function can limit distractions. For example, the Infrared Thermometer in the toolkit only has one function, to measure surface temperature.

The **Capturing Your Environment (CYE) Framework** uses DOTS in the 5E Instructional Model to address specific learning goals inspired by the Essential Principles of Climate Literacy and the Next Generation Science Standards (NGSS), as outlined on the next page. The CYE Framework sets a foundation for learners to gain STEM skills and experiences to use as future scientists.

The Five E's[1]

Learning objectives for each "E" throughout the lesson framework.



1 Bybee, R., & Landes, N. M. (1990). *Science for life and living: An elementary school science program from Biological Sciences Curriculum Study (BSCS)*. The American Biology Teacher, 52(2), 92–98. https://doi.org/10.2307/4449042.

Next Generation Science Standards (NGSS, 2013)

3-ESS2-1 Earth's Systems Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season.	**Grade:** 3–5, 3
5-ESS2-1 Earth's Systems Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.	**Grade:** 3–5, 5
MS-LS2-5 Ecosystems: Interactions, Energy, and Dynamics Evaluate competing design solutions for maintaining biodiversity and ecosystem services.	**Grade:** Middle School (6–8)
MS-ESS2-5 Earth's Systems Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.	

Essential Principles of Climate Literacy (USGCRP, 2009)

1	The sun is the primary source of energy for Earth's climate system.
2	Climate is regulated by complex interactions among components of the Earth system.
3	Life on Earth depends on, is shaped by, and affects climate.
4	Climate varies over space and time through both natural and man-made processes.
5	Our understanding of the climate system is improved through observations, theoretical studies, and modeling.
6	Human activities are impacting the climate system.
7	Climate change will have consequences for the Earth system and human lives.

Lesson Objectives

- Collect and organize data using digital mobile technology to measure temperature and weather conditions.
- Design solutions that reflect data analysis and an understanding of the relationship between the environment and the collected data.

What's in the Kit?

Troubleshooting Guide (link)

Infrared (IR) Thermometer

Purpose: Quickly measures surface temperature without making contact with the object

How to use

WARNING: DO NOT POINT AT ANYONE'S HEAD. May cause eye damage if shined in the eyes.

1. Turn on the IR Thermometer by pressing the center button labeled, "**°C/°F**." The center button toggles the temperature scale from Celsius to Fahrenheit and back again.
   a. Once at Fahrenheit, be sure to continue to use this unit of measurement.
2. Aim the thermometer at an object and hold down the button on the back using your index finger.
3. A red light will appear on the object you are measuring.
   a. **NEVER** point the red light at anyone's head.
4. Note the temperature that appears on the screen.
5. Record the findings.
   a. Include the object and the unit of measurement (°C/°F).
6. After you're done, put the tool back in the case.
7. The thermometer turns off automatically.

Kestrel 2000 Pocket Weather Station

Purpose: Quickly measures wind speed, wind chill, and air temperature

How to use

1. Turn on the Kestrel 2000 Pocket Weather Station by pressing the power button located in the middle under the screen.
2. [dEG] The first measurement should be temperature in degrees Fahrenheit.
   a. To change the units (e.g.,. °C to °F), press the center button and the right button at the same time.
3. Press the arrows to begin seeing the different data. They are as follows (by pressing right):
   a. **[chill] Wind Chill**—This measures how cold it feels when the wind and the temperature are combined together. Measured in Fahrenheit (°F).
   b. **[SPd] Wind Speed**—This measures the speed of the wind; hold the Kestrel perpendicular to the wind direction. Measured in miles per hour (mph).
   c. **[MAX] Max Wind Speed**—This measures the highest wind speed for the amount of time the device has been turned on. Measured in miles per hour (mph).
   d. **[AVG] Average Wind Speed**—This displays the overall wind speed for the amount of time the device has been turned on. Measured in miles per hour (mph).
4. Turn off the instrument by holding the power button.

Additional Supplies

Materials Folder: This folder includes lesson plan documents, data recording sheets, and any supplemental materials needed for the activities.

Red Stake Flags: These flags can be used to determine wind direction or be placed to mark specific points to measure.

Location Selection

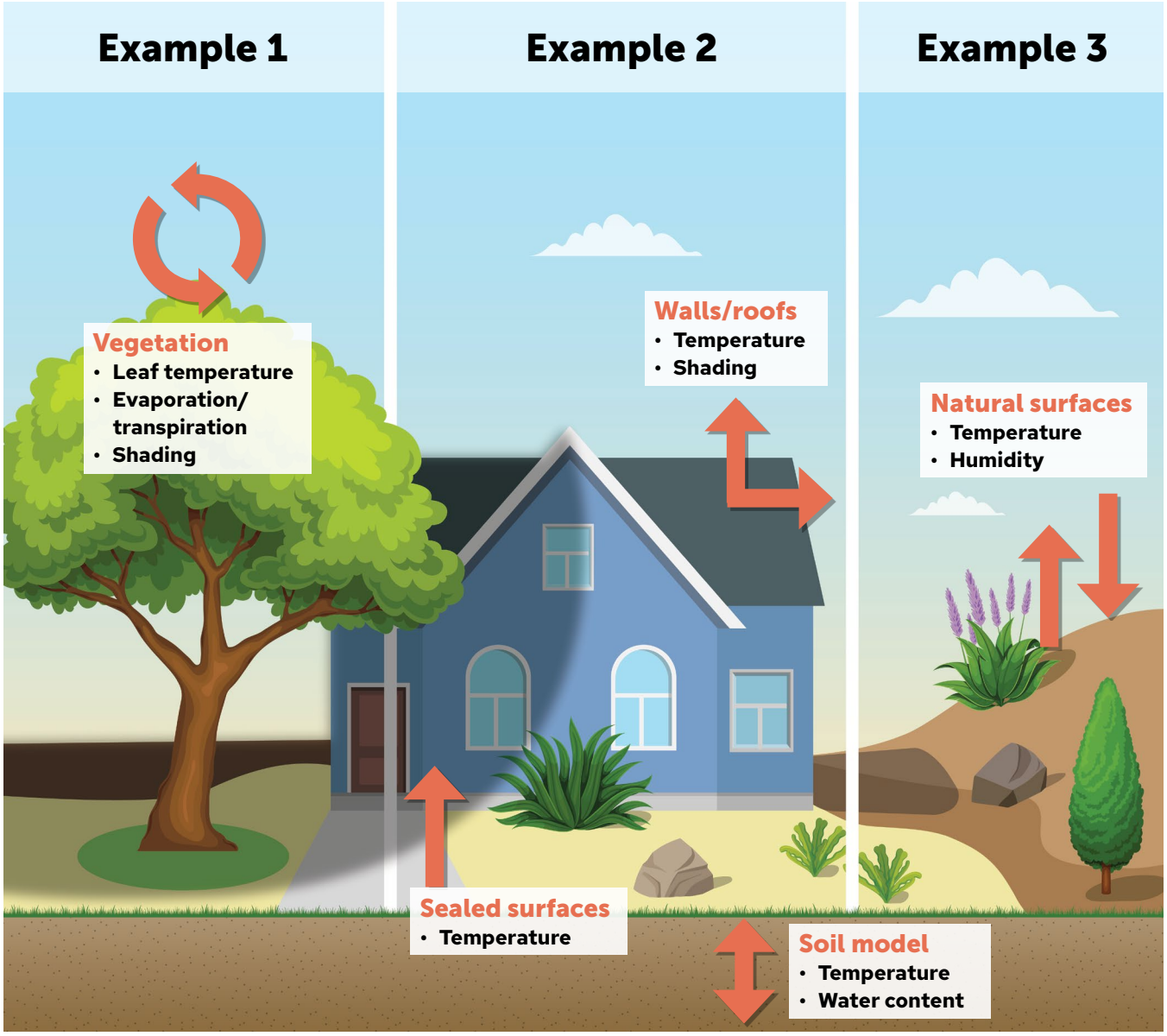
1	Look for a site that includes a variety of natural and/or man-made features.
2	Provide a map of the area if possible.
3	Mark clear boundaries on the map.

TERMINOLOGY

Microclimate

Microclimate: A local set of environmental conditions that are different from the surrounding areas

Examples: Shaded wooded area versus cornfields; beach versus parking lot



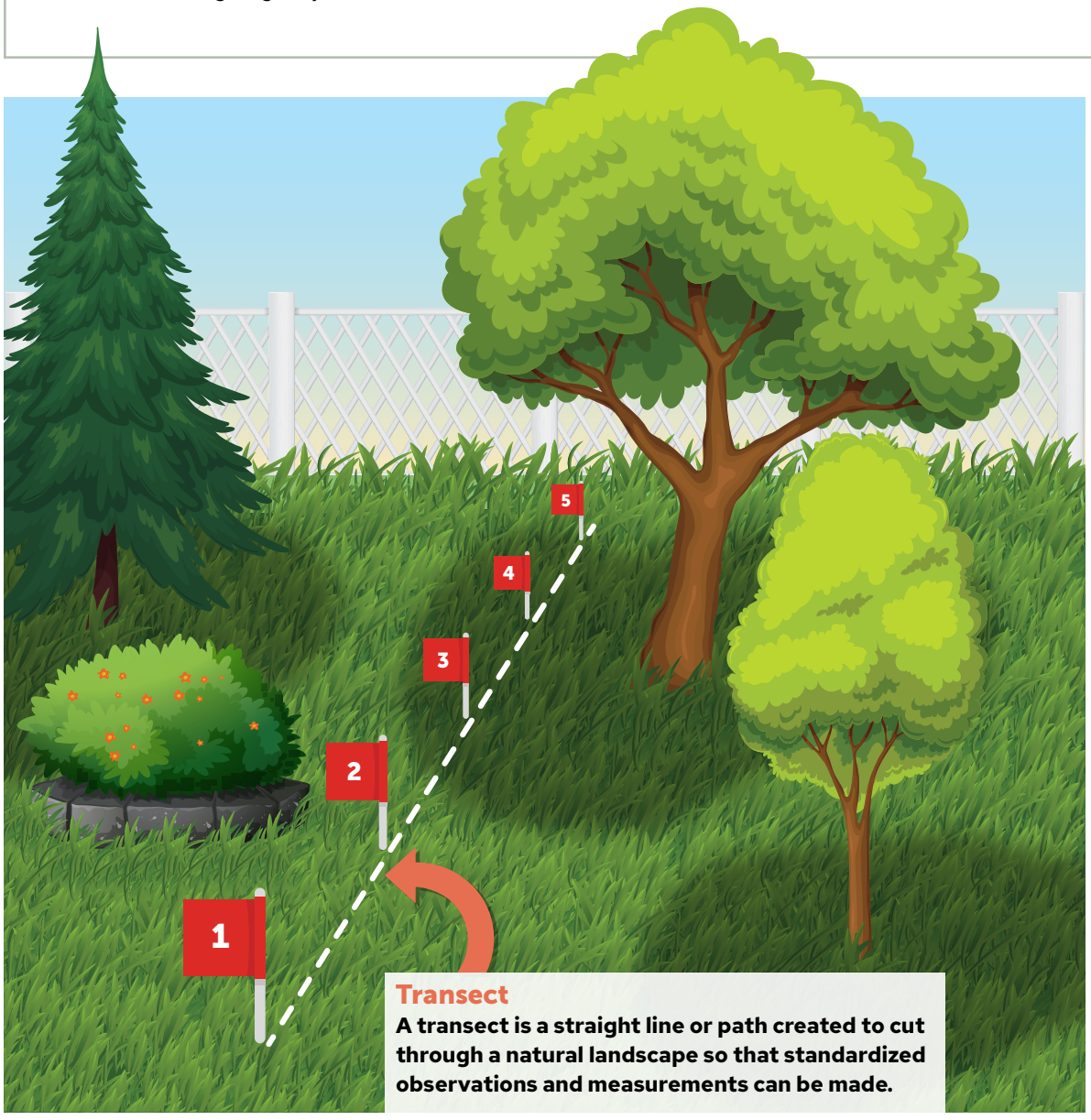
TERMINOLOGY

Transect

Transect: A straight line or path created to cut through a natural landscape so that standardized observations and measurements can be made.

Lesson Considerations

- If possible, have several locations where the transect(s) can be located.
- To provide the learners with contrasting environments, locate a transect that includes both a modified space (e.g., cement, wood chips, grass) and a natural space (e.g., brush, trees, wildflowers).
  - For example: A transect that begins at a sidewalk and crosses through a grassy or shaded area.
- This allows for learners to identify at least one significant contributor to the urban heat island effect.
- Individual groups can create transects in different locations (modified vs. natural).
  - Data can then be compared and contrasted if the time data that was collected is similar.
- To learn more about transects, visit nps.gov/articles/000/what-are-transects.htm.



TERMINOLOGY

Urban Heat Island

Urban heat island: An increase in local temperatures, change in wind patterns, and declining air quality, in cities due to the replacement of natural land cover with dense concentrations of pavement, buildings, and other surfaces that absorb and retain heat (WMO, 2020).

Materials

Copies of the necessary paper materials are stored in the red materials folder. Depending on group size, determine how many learners will share the tools.

Materials per group

- 1 IR Thermometer and 1 Kestrel Weather Station
- 1 data collection sheet
- 1 quick learning guide
- 1 learner workbook
- 5 red stake flags
- Clipboards and pencils
- (Optional) map of the location
- Timekeeping device
- Black dry-erase marker

Each learner will complete a **Self-Assessment** before and after the lesson.

Capturing Your Environment

ENGAGE

Community Connections

Lesson Slide Deck (link) **Administer Self-Assessment (before)**

Essential Question
How does making changes to an environment affect its temperature and wind conditions over time?

Activator Draw a picture of what you think the **climate** is.

Facilitator

Ask:
- What did you include in your drawings? Did anyone draw buildings or a city?
- Do you think it is hotter in a city compared to outside of a city? Why or why not?

Watch:
- Introduction video (link)
  - This video introduces an issue that affects cities due to factors such as heat and wind that are present within its microclimate, called urban heat islands.

Discuss:
- Do you think your community is affected by these issues?
  - What have you seen or heard that supports your thinking?
  - Does it matter? Why or why not?

Tool Introduction:
- Use **slides 8–13** in the slide deck or the **Tool Description Guide** to introduce the tools.

Form Groups:
- Be sure there are enough tools to be shared amongst the group members.

EXPLORE

Walk Through—Free Exploration

Facilitator Questions to ask during the lesson:
- How can you use the tools to help answer your questions?
- How do you accurately record information collected from the outdoors?

1. **Prepare for the activity**

- Carry the kit(s) to a central area near the predetermined outdoor location(s).
- Gather learners and review tool safety and care.

2. **Observe the environment without tools:**

- Invite the learners to explore the designated area and notice any differences/similarities in temperature, vegetation, or sunlight (3 minutes).
  - Have learners walk around the area, noticing the differences in shade, light, heat, and wind without the tools.
  - The designated area should also include features that have been changed or modified (e.g., cement; fences; woodchips).
  - When the exploration without tools is complete, begin the next step.

3. **Observe the environment with an IR Thermometer**

- Hand out the IR Thermometer to each learner or 1 per group, depending on the number of learners.
- Hand out 1 **Learner Workbook** per group.
- When the timer begins (3 minutes), have the learners use the IR Thermometer to find the hottest targets, coldest targets, and think of questions.
- Encourage them to write their questions down in the **Learner Workbook** after the exploration.
- Collect the IR Thermometers.

4. **Observe the environment with a Kestrel Weather Station**

- Hand out the Kestrel Weather Station and give the learners time to explore with this tool. (3 minutes)
- While using the tool, have the learners pay attention to what stays the same, what changes, and possible reasons for those changes.
- Encourage learners to think of any questions they have after using the tool and write them in the group's **Learner Workbook**.
- Collect the weather stations.

5. **Call learners back to the central meeting place and lead debrief**

- As a whole group or in small groups, complete Debrief #1 in the **Learner Workbook**.

Debrief #1 (Learner Workbook)

Facilitator Ask: What were some of the differences/similarities you noticed when you used your senses versus when you used the measurement tools?

EXPLAIN

Lesson Objectives

- Collect and organize data using digital mobile technology to measure temperature and weather conditions.
- Design solutions that reflect data analysis and an understanding of the relationship between the environment and the collected data.

Explore the Quick Learning Guide

Facilitator Ask learners questions to prompt exploration of the Quick Learning Guide:

- What are some words you can use to describe the environment you're exploring today? Could any more be added?
- Would your descriptions change if you were on a beach or in a forest even though they may be in the same city?
- How would you describe this space's current wind and temperature conditions? What might be the cause?

1. Direct learners to notice the different science terminology in the **Quick Learning Guide**.
   a. Look at the description and picture of a microclimate. Discuss with the group what a microclimate is and informally assess the group's understanding.
   b. Look at the description and picture of an Urban Heat Island. Discuss with the group what an urban heat island is and informally assess the group's understanding.
   c. Look at the description and picture of a transect. Discuss with the group what a transect is and informally assess the group's understanding. If a predetermined transect was established, this is the time to share the starting point, each point in between, and the endpoint.

Facilitator What are some key features of a transect and why do you think we should use it when measuring a specific area?

To build understanding on what a *transect* is:

2. Give several learners a flag and ask them to line up as a visual representation while explaining.
   - Demonstrate taking large steps to measure between each of the five flags
   - Have a learner number the flags using the black dry-erase marker.
3. State that the purpose of each flag is to help us measure the same point each time we come back to the space.

Adaptations to clarify concepts (if time allows)

4. Travel together to the different spaces and notice where the microclimates change.
5. Ask the youth questions as they are in that space.

   Facilitator
   - What does the air feel like?
   - What does the ground feel like?
6. As the group moves from space to space, point out that they are moving from microclimate to microclimate.

ELABORATE

Collecting Data Along a Transect

1. **Discuss how to choose a transect (if a transect has not been predetermined):**
   - Have learners discuss, either in a whole group or in their small groups, areas that may be interesting to gather data.
   - Make sure they talk about modified or "man-made" spaces, contrasting hot and cold targets, differences in the number of trees in one area compared to another, or an area with lots of temperature differences.
2. **Choosing a transect:**
   a. Ask each group to begin to establish their own transects with their DOTS kits. Monitor learners who choose to include spaces such as public sidewalks, public parking lots, or areas close to traffic.
   b. Instruct learners to establish the transect by measuring a straight line with an equal amount of steps between each point on the line, marking each point with a red stake flag. Using the black dry-erase marker, number each flag 1 through 5. If tools are available, they can use a measuring tool or a rope to create a transect with equal spacing between each point and a straight line from start to finish.

3. **Measurement steps along the transect:**

   At each point along the transect, learners:

   Describe

   - The time that measurements were taken
   - The weather conditions ("it got windy suddenly")
   - The features of the point (surface material, sun/shade, etc.)
   - Ground cover (sandy, rocky, grassy, etc.)

   Measure

   - Wind in mph at a consistent height
   - Temperature of air
   - Temperature of ground where the red stake flag is placed

Debrief #2 (Learner Workbook)

During this debriefing session, help the learners make connections between the data and the microclimate that exists in the space.

Facilitator Ask: How are the heat, air temperature, wind speed, etc., affecting the area?

EVALUATE

Design

Facilitator Questions to consider:

- How could climate issues be resolved by designs?
- Are there ways microclimates support human life and plant life equally?
  - Can those characteristics be replicated?
- What are some of the characteristics that make a microclimate unique from the local or global climate?

Designing and evaluating solutions

The final steps of the lesson will include an opportunity for the learners to go back to their original questions and try to answer them using their data.

1. **Guide design thinking**
   - Give learners time to think of innovative ways to modify the microclimate to support plant growth.
   - Discuss ideas with the group or have groups individually share ideas.
   - Hand out or display the **Design Outcome Examples** page if learners are having a difficult time brainstorming. This document will be helpful to facilitate discussion.
     - The **Evaluation Options** page provides alternative artifacts directly connected to the NGSS grade-level standards.
2. **Learners design solutions**
   - Give learners time to design a solution to address these issues.
   - Hand out **Evaluation Artifact and Rubric** to learners to draw out their designs and apply their collected data.

Administer Self-Assessment (after)

Design Outcome Examples

The design solutions should reflect the learners' understanding of:

- The environment where they are collecting data
- The effect of the altitude, precipitation, shade, sunlight, wind speed
- How modifications made to the environment may affect the collected data over time

If accomplished, learners will have demonstrated their understanding of the local *microclimate*.

Design Solution Examples (van Gool, n.d.)

1. Increase **vegetation** to reduce wind impact.
2. Add **water storage** to modify temperature fluctuations.
3. Introduce **small bodies of water** (e.g., lakes or ponds) to modify heat and add light reflection.
4. Add a **greenhouse or polytunnel** to help buffer extreme temperatures.
5. Plant **trees or add vegetation** to give a cooling effect.
   - This is as a result of shade and evaporation, which creates cooling.
6. **Paint walls white** to reflect light into darker, shadier areas and improve growth and ripening.
   - Dark walls reduce frost risk by staying warmer.
7. **Use thermal mass** (e.g., rocks or stone walls) to absorb heat. Plant more tender plants close to them.
8. Create a natural **root cellar** for food storage in the earth without energy-based refrigeration.
9. **Sun traps** create shelter from cold and destructive winds by capturing maximum sunlight all day.
10. **Hot beds** are created by placing small glass frames on top of piles of manure, which generate heat as they rot.

Modified from www.freepermaculture.com/season-extension-microclimates

Learning Objectives

- Collect and organize data using digital mobile technology to measure temperature and weather conditions.
- Design solutions that reflect data analysis and an understanding of the relationship between the environment and the collected data.

Evaluation Options for Next Generation Science Standards (NGSS, 2013)

Standards	Product Option	Examples
3-ESS2-1 Earth's Systems Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season. **Grade:** 3–5, 3	Create a bar graph using collected data to compare the environmental conditions over time.	**Data could include:** • Average temperature • Precipitation • Wind direction
5-ESS2-1 Earth's Systems Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact. **Grade:** 3–5, 5	Develop a model that illustrates how sunlight impacts the soil and plant life in the measured environment.	**Models could include:** • The influence of the ocean on ecosystems, landform shape, and climate; • The influence of the atmosphere on landforms and ecosystems through weather and climate; • The influence of mountain ranges on winds and clouds in the atmosphere. *Note:* The geosphere, hydrosphere, atmosphere, and biosphere are each a system.
MS-LS2-5 Ecosystems: Interactions, Energy, and Dynamics Evaluate competing design solutions for maintaining biodiversity and ecosystem services. **Grade:** Middle School (6–8)	Develop and defend a design solution that attempts to maintain biodiversity and ecosystem services.	**Ecosystem services could include:** • Water purification, nutrient recycling, and prevention of soil erosion. **Design solution constraints could include:** • Scientific, economic, and social considerations.
MS-ESS2-5 Earth's Systems Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions. **Grade:** Middle School (6–8)	Organize data by creating a table, graph, or other method that displays the collected data accurately and clearly.	**Data could demonstrate:** • How air masses flow from regions of high pressure to low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time. • How sudden changes in weather can result when different air masses collide. **Data can be provided to learners** (weather maps, diagrams, and visualizations) **or obtained through exploration and data collection.**

LEARNER RUBRIC

"Capturing Your Environment" Lesson Evaluation

1. The design makes life better for plants, humans, or both.	Yes or No
2. The design uses data from previous measurements.	Yes or No
3. I used labels to show what was included in the design.	Yes or No
4. I used labels or arrows to show how the environment will or will not change over time.	Yes or No

Drawing of Design Solution

What materials do you plan to use?

What measurements did you use to help make this drawing?

What is your prediction for how the measurements of this space will change in the future?

FACILITATOR RUBRIC

"Capturing Your Environment" Lesson Evaluation

Learner Name _____

The design attempts to change the environmental condition to support its sustainability.		
1	**2**	**3**
The design did not include elements that showed understanding of how to change the environmental conditions.	The design showed understanding of how to change the environmental condition, but little effort was made to elaborate on the overall design.	The design included elements that showed an understanding of how to change the environmental conditions of the microclimate and details were added to explain how.

The design uses data from previous measurements.		
1	**2**	**3**
The design did not include any reference to data.	The design showed some reference to data, but the selected data was not relevant to the design.	The design showed some reference to data that was relevant to the design.

Learner Name _____

The design attempts to change the environmental condition to support its sustainability.		
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The design did not include elements that showed understanding of how to change the environmental conditions.	The design showed understanding of how to change the environmental condition, but little effort was made to elaborate on the overall design.	The design included elements that showed an understanding of how to change the environmental conditions of the microclimate and details were added to explain how.

The design uses data from previous measurements.		
1	**2**	**3**
The design did not include any reference to data.	The design showed some reference to data, but the selected data was not relevant to the design.	The design showed some reference to data that was relevant to the design.

OUTDOOR LESSON STEPS

Explore the outdoor space:

- Use your senses to describe what you notice.
  - Examples: "I can feel heat rising off of the cement." or "I can see the shade from the trees."
- Use the IR Thermometer to explore the temperature of objects.
- Use the Kestrel Weather Station to explore the current weather conditions.

Pick-Up Learner Workbook

- Use the Learner Workbook to write down questions you have about what you explored.

Debrief #1 (with group)

- Respond to prompt in the Learner Workbook.

Locate the starting point of the transect

- If a transect needs to be made, plant flags at an equal distance apart until the endpoint is reached.
- Number each flag using the black dry-erase marker.
- If a transect is premade, begin collecting data starting at Flag #1.

Gather data at each flag using the measurement tools

- Record the data using the Data Collection Sheet.

Debrief #2 (with group)

- Respond to prompt in the Learner Workbook.

Reflect

- Describe what you notice about the data.

Design

- Draft a design solution for the space that could make a change to its measured microclimate conditions.
- Explain how the design solution impacts the environmental conditions.

Self-Assessment

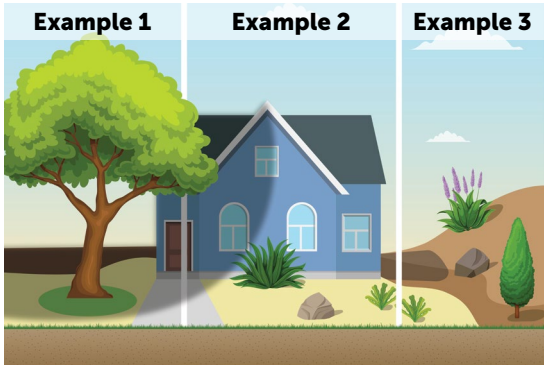
QUICK LEARNING GUIDE

Learning Objectives

- Collect and organize data using digital mobile technology to measure temperature and weather conditions
- Design solutions that reflect data analysis and an understanding of the relationship between the environment and the collected data

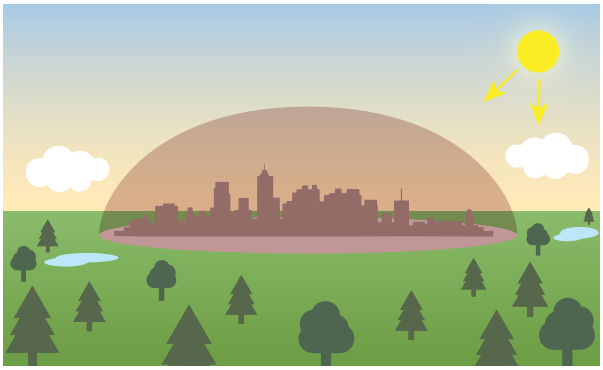
Microclimate: An area where the wind, heat, light, or water level patterns are different from surrounding areas.

Examples: Shaded wooded area versus cornfields; beach versus parking lot

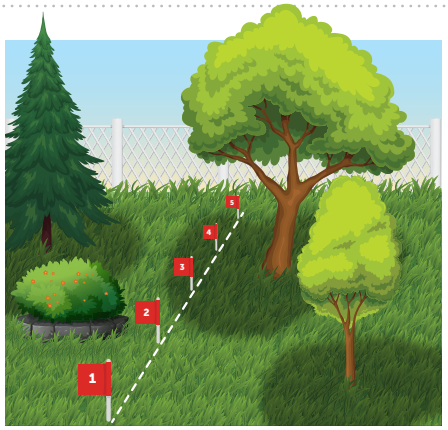


Urban Heat Island: When temperatures in a city are higher on average because of more pavement, buildings, and other surfaces that keep in heat.

An *urban heat island* is an example of a **microclimate**.



Transect: A straight line used to make observations the same every time you measure on or around a point.



Location Descriptors

Surface	Sandy, rocky, grassy, cement, soil, mud, asphalt, uneven (hill or flat), etc.
Vegetation	Leafy, trees, bushes, flowers, grasses, bindweed, thistle, vegetables, fruits, natural, etc.
Animals	Insects (types), birds, mammals, etc.
Pollution	Plastics, glass, trash, oil, etc.

DATA COLLECTION SHEET

Date ______________________________

Flag #:	Time	Location Description	Current Weather Condition	Wind Speed (mph)	Ground Temp. (°F)	Ground Cover	Air Temp. (°F)
			Circle: Cloudy, sunny, rainy, windy, humid ______________ ______________				

Flag #:	Time	Location Description	Current Weather Condition	Wind Speed (mph)	Ground Temp. (°F)	Ground Cover	Air Temp. (°F)
			Circle: Cloudy, sunny, rainy, windy, humid ______________ ______________				

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			Circle: Cloudy, sunny, rainy, windy, humid ______________ ______________				

LEARNER WORKBOOK

What did you notice after exploring? What did you see? Feel? Hear?

What question(s) do you have after using the IR Thermometer and Kestrel Weather Station?

DEBRIEF #1

What were some of the differences/similarities you noticed when you used your senses vs. when you used the measurement tools?

DEBRIEF #2

How is the heat, air temperature, wind speed, etc., changing the area?

REFLECT

Describe the microclimate of the space you measured on the transect. What could be the causes of these conditions?

SELF ASSESSMENT BEFORE

1. I have the skills required to be successful in science and technology learning.

1	2	3	4
STRONGLY DISAGREE	DISAGREE	AGREE	STRONGLY AGREE

2. I think it is important to learn about science and technology.

1 ..... **2** ..... **3** **4**

3. I know how to use a Kestrel Weather Station to measure the weather conditions.

1 ..... **2** ..... **3** **4**

4. I know how to use an Infrared Thermometer to measure surface temperatures.

1 ..... **2** ..... **3** **4**

5. I can describe what a *microclimate* is.

1 ..... **2** ..... **3** **4**

6. I know how to collect, organize, and interpret data.

1 ..... **2** ..... **3** **4**

7. I can see myself using science and technology in the future.

1 ..... **2** ..... **3** **4**

SELF ASSESSMENT AFTER

1. I have the skills required to be successful in science and technology learning.

1	2	3	4
STRONGLY DISAGREE	DISAGREE	AGREE	STRONGLY AGREE

2. I think it is important to learn about science and technology.

1 ..... **2** ..... **3** **4**

3. I know how to use a Kestrel Weather Station to measure the weather conditions.

1 ..... **2** ..... **3** **4**

4. I know how to use an Infrared Thermometer to measure surface temperatures.

1 ..... **2** ..... **3** **4**

5. I can describe what a *microclimate* is.

1 ..... **2** ..... **3** **4**

6. I know how to collect, organize, and interpret data.

1 ..... **2** ..... **3** **4**

7. I can see myself using science and technology in the future.

1 ..... **2** ..... **3** **4**

8. The instructor was knowledgeable about the topics that were discussed today.

1 ..... **2** ..... **3** **4**

9. The instructor was well-prepared for today's activities.

1 ..... **2** ..... **3** **4**

Capturing Your Environment (CYE) Framework:

Exploring Microclimates Using Infrared Thermometers and Kestrel Weather Stations

FACILITATOR GUIDE • JULY 2025

Authors

Brad Bessler
Brad is an educator and education researcher affiliated with the University of Wisconsin–Milwaukee and the University of Wisconsin–Madison Division of Extension. His work focuses on environmental education, STEM learning, and equitable instructional design across both formal and informal learning environments. Through his role at UW–Madison Extension, Brad supports youth programming and curriculum development aimed at expanding access to meaningful, place-based learning experiences for diverse learners.

Dr. Justin Hougham
Justin is a Positive Youth Development State Specialist and faculty member at the University of Wisconsin–Madison, where he supports the delivery of science education to K–12 students, graduate students, and in-service teachers. His scholarship focuses on place-based pedagogies, STEM education, experiential education, and environmental literacy initiatives.

Editors

Monica Lobenstein
Tarah DeClemente
Emery Bork

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Authors: Brad Bessler; Dr. Justin Hougham

Editors: Monica Lobenstein; Tarah DeClemente; Emery Bork

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