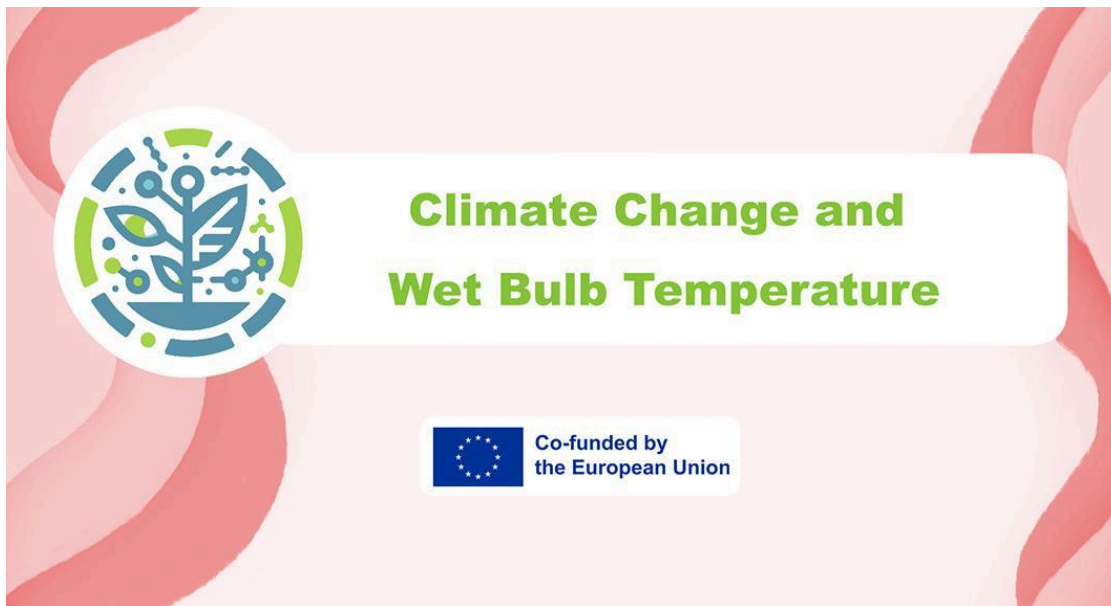




Steam4Climate Teacher's Guide to Project-Based Climate Education

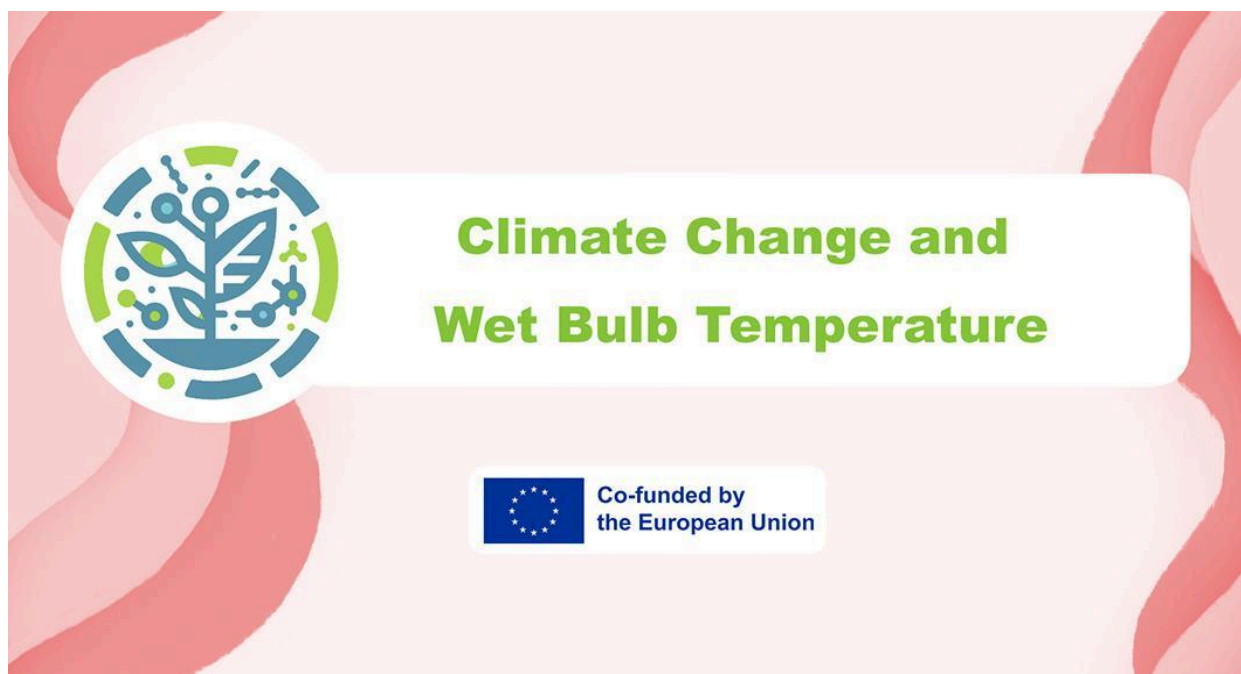
Project: Climate Change and Wet Bulb Temperature

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Table of Contents

TABLE OF CONTENTS.....	3
INTRODUCTION.....	4
1. LEARNING OVERVIEW.....	5
2. LEARNING OBJECTIVES.....	6
3. METHODOLOGY.....	7
A “LOW FLOOR, HIGH CEILING, WIDE WALLS” APPROACH.....	8
4. MATERIALS.....	9
5. EXPERIMENT PROCEDURES.....	11
6. EXAMPLES OF ARTEFACTS.....	12
7. POST LESSON FOLLOW-UP & SUMMARY.....	14
7.1 DISCUSSION TOPICS.....	14
7.2 INTEGRATING LEARNING ACROSS DISCIPLINES.....	15
7.3 SUMMARY.....	15
8. EXTENSIONS.....	16

Introduction

UN Sustainable Development Goals



This guide is a teacher-focused manual containing all content needed to conduct the lessons, guide the experiments, and prepare students for project-based tasks. It includes technical and practical details necessary for lesson planning.

This project addresses UN Sustainable Development Goals 3 (Good Health and Well-being) and 13 (Climate Action) by exploring how heat and humidity affect human health in a warming climate. Through this activity, students will investigate how increasing temperature and atmospheric moisture can challenge the body's natural ability to cool itself, linking personal experience to broader climate and sustainability issues.

In this hands-on, interdisciplinary project, students will conduct a series of experiments and simulations to understand the concept of wet bulb temperature—a measure that combines air temperature and humidity to indicate how effectively humans can cool down through evaporation. By experimenting with different environmental conditions and materials, they will gain insight into the physical and biological principles behind thermoregulation, while reflecting on how climate change amplifies heat-related risks for people and ecosystems.

1. Learning Overview

In this project, students explore how temperature and humidity interact to influence the human body's ability to regulate heat. They will learn about the concept of wet bulb temperature, which reflects the combined effect of heat and moisture on human thermoregulation. By performing hands-on experiments and digital simulations, students will gain insight into how climate change intensifies heat stress and why certain environmental conditions can become dangerous for humans and other living beings.

This activity connects physics, biology, and climate science, offering students a practical way to understand the physical laws of heat transfer, evaporation, and energy balance in living systems. The project is ideal for developing critical thinking, teamwork, and data interpretation skills, while encouraging students to reflect on the social and environmental dimensions of rising global temperatures.

Key Concept:

Understanding how heat and humidity interact through the wet bulb temperature effect and how this relationship affects human health and climate resilience.

Duration: Approximately 5–6 hours (can be extended with simulation and sensor-based activities).

Number of Sessions: 3–4 classroom sessions (including theoretical discussion, experiments, and reflection).

Target Age Group: Secondary school students, ages 13+.

2. Learning Objectives

This project offers students an engaging and interdisciplinary experience that integrates scientific experimentation, critical thinking, and environmental awareness. By combining physics and biology concepts, students explore how temperature, humidity, and evaporation interact to affect the human body's ability to maintain balance in a warming world.

By the end of this project, students will be able to:

- Understand the concept of wet bulb temperature and explain how it combines temperature and humidity into a single measure of heat stress.
- Describe the biological processes of thermoregulation and the role of evaporation in cooling the body.
- Investigate how environmental factors such as humidity and wind influence the body's ability to release heat.
- Conduct hands-on experiments that measure cooling effects under different humidity conditions using basic laboratory materials.
- Collect and analyze quantitative and qualitative data to compare observed results with theoretical expectations.
- Interpret experimental findings in relation to real-world climate and health challenges, including heatwaves and global warming.
- Reflect on adaptation and mitigation strategies to protect human health in a changing climate.
- Collaborate creatively to design solutions or awareness projects (e.g., microcontroller-based sensors, data visualizations, or public campaigns).

3. Methodology

Teachers are encouraged to combine **hands-on experimentation** with **guided reflection** and **discussion** to help students connect physical and biological concepts to real-world climate impacts. This project supports a **Project-Based Learning (PBL)** approach, where learners explore complex systems through observation, measurement, and creative problem-solving.

The methodology integrates several complementary learning modes:

- **Hands-on experimentation:** Students actively perform experiments to observe how temperature and humidity affect evaporation and body cooling.
 - **Scientific inquiry and analysis:** They collect, compare, and interpret data to uncover patterns between environmental factors and thermal comfort.
 - **Reflective discussion:** Students discuss the implications of their findings — connecting them to climate change, human health, and community well-being.
 - **Collaborative exploration:** Through teamwork, students share ideas, assign roles, and co-create projects that extend their learning beyond the classroom.
 - **Creative synthesis:** Learners are encouraged to design and communicate solutions — such as awareness posters, prototype heat sensors, or adaptation strategies for vulnerable populations.
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A “Low Floor, High Ceiling, Wide Walls” Approach

In the STEAM4Climate framework, this project embodies an inclusive learning design that enables every student to participate meaningfully — from simple observations to advanced experimentation and design.

Low Floor: All students can begin with simple, accessible experiments — for example, observing the cooling effect of evaporation using thermometers, paper towels, and water or alcohol. These low-threshold tasks allow everyone to engage immediately with the core scientific concept.

High Ceiling: Advanced learners can extend their exploration by designing and building digital weather stations or heat-stress monitors using microcontrollers (e.g., BBC Micro:bit or WIO Terminal) and humidity sensors. They can also analyze regional climate data to explore real-world heatwave patterns and critical wet bulb thresholds.

Wide Walls: The project encourages diverse pathways for creativity and expression. Students can visualize their data artistically, connect their experiments to social issues such as climate justice or public health, or develop communication campaigns to raise community awareness. Each learner’s approach contributes to a broader understanding of how science, society, and climate intersect.

4. Materials

The materials listed below support both the **basic experiments** for understanding the wet bulb temperature concept and the **extended activities** for deeper exploration using digital tools or creative applications. Teachers can adapt the setup based on available classroom resources and student experience levels.

Unit 1: Approaching the wet bulb temperature through experiments

- **Experiment 1: Evaporative Cooling:**
 - Pipette
 - Isopropanol (or ethanol, Benzinum medicinale)
 - Optional: Water, pentane, ethanol

- **Experiment 2: Quantitative Measurement of Evaporative Cooling:**
 - Pipette
 - Two thermometers
 - Paper towels
 - Isopropanol
 - Small USB-powered fan

- **Experiment 3: Qualitative Wet Bulb Temperature Measurement:**
 - Pipette
 - Two thermometers
 - Paper towels
 - Erlenmeyer flask
 - Cotton wool

- **Experiment 4: Measuring Body Temperature at Rest and During Activity:**

- Infrared thermometer or ear thermometer
- Optional: Water sprayer

Project-Based Learning

- **Unit 2: Constructing a Weather Station (for Younger Students):**

- BBC Microbit: <https://microbit.org/buy/bbc-microbit-go/>
- Kitronik OLED Display for Microbit:
<https://kitronik.co.uk/products/56115-kitronik-view-graphics128-oled-display-128x64-for-bbc-micro-bit>
- DHT22 Temperature and Humidity Sensor:
<https://www.az-delivery.de/products/dht22-temperatursensor-modul>
- Computer with internet access

- **Unit 2: Constructing a Weather Station (for Older Students):**

- Seeed Grove WIO Terminal:
<https://www.berrybase.de/seeed-wio-terminal-atsamd51-core-development-board-wifi-bluetooth>
- Seeed Grove SHT31 Temperature and Humidity Sensor:
<https://eu.robotshop.com/de/products/grove-temperatur-feuchtigkeitssensor-sht31>
- Computer with internet access

5. Experiment Procedures

Experiment 1: Evaporative Cooling

- **Objective:** Understand evaporative cooling as a biological and physical phenomenon.
- **Procedure:** Drop isopropanol on the back of the hand to observe the cooling effect. Students can experiment with different liquids to compare cooling efficiency.

Experiment 2: Quantitative Measurement of Evaporative Cooling

- **Objective:** Record evaporative cooling as a measurable physical phenomenon.
- **Procedure:** Two thermometers are set up, one wrapped in a damp paper towel. Measure and compare the cooling effect.

Experiment 3: Qualitative Wet Bulb Temperature Measurement

- **Objective:** Understand how the saturation of air affects cooling efficacy.
- **Procedure:** Set up two thermometers, one in saturated air inside an Erlenmeyer flask. Measure the difference in cooling effects.

Experiment 4: Body Temperature During Rest and Exercise

- **Objective:** Explore how the body dissipates heat.
- **Procedure:** Measure a student's body temperature at rest, then after physical activity. Optionally, spray water on one arm to compare cooling efficiency between sweating and non-sweating conditions.

Simulation Tools

Wet Bulb Temperature Simulator: A digital tool to help students visualize when critical wet bulb temperatures are reached under different humidity conditions. Access it here: <https://iludis.de/wetBulbTemp/index.html>

6. Examples of Artefacts

The experiments in this project can lead to a wide range of artefacts that showcase both scientific understanding and creative expression. Students are encouraged to document, visualize, and communicate their results in engaging ways that connect data, design, and climate awareness.

6.1 Experimental Artefacts

Students can create small experimental setups and visual displays that demonstrate key phenomena explored in class. Examples include:

- A wet bulb thermometer model using two thermometers (dry and wrapped in a damp cloth), displayed as part of a poster or classroom station.
- A table or chart comparing “dry bulb” and “wet bulb” readings under different humidity levels.
- A simple laboratory setup photograph showing their process for measuring temperature differences.
- A handmade humidity chamber (e.g., using an Erlenmeyer flask or plastic container) illustrating how saturated air limits evaporation.
- These artefacts can be exhibited in the classroom to help other students visualize the relationship between temperature, humidity, and cooling.

6.2 Digital Artefacts

Students who work with microcontrollers or simulations can present their findings digitally. Possible artefacts include:

- A digital weather station that displays temperature and humidity data in real time using a Micro:bit or WIO Terminal.
- A simulation screenshot or graph showing how wet bulb temperature changes under varying conditions.
- An interactive infographic or short video explaining heat stress thresholds and their global implications.
- A data visualization project comparing recorded classroom data with real meteorological records.

6.3 Creative and Reflective Artefacts

Encourage students to combine science with creativity to express the human and societal aspects of the topic. Ideas include:

- Art-based interpretations such as drawings or collages visualizing “heat and humidity” or “climate discomfort.”
- Storytelling or poster projects that communicate heatwave preparedness and adaptation strategies.
- Awareness campaigns (digital or physical) encouraging sustainable behaviors that mitigate heat impacts in urban environments.

7. Post Lesson Follow-up & Summary

After completing the experiments, encourage students to reflect on their observations, analyze results, and connect their learning to real-world contexts. This stage transforms scientific discovery into critical thinking about climate change, health, and human adaptation.

7.1 Discussion Topics

Use the following questions to facilitate class discussions or reflective journal writing. They help students link their experimental results to global and societal challenges.

Understanding the Science

- Why does high humidity make hot weather feel more uncomfortable?
- What happens to the body when the wet bulb temperature exceeds 35°C?
- How do temperature and humidity work together to influence the rate of evaporation?
- Why is the difference between dry and wet bulb readings smaller on humid days?

Connecting to Climate Change

- How does global warming influence the frequency and intensity of heatwaves?
- Which regions of the world are most at risk from rising wet bulb temperatures?
- What kinds of populations (e.g., outdoor workers, elderly, children) are most vulnerable to heat stress, and why?
- How can urban design or green infrastructure help reduce heat exposure?

Reflecting on Solutions

- What adaptation measures can individuals take to stay safe during extreme heat?
- How can science and technology support climate resilience?
- If you could design a campaign, what key message would you want to share?

Encourage students to compare their reflections with their experimental data.

7.2 Integrating Learning Across Disciplines

This project naturally connects to multiple areas of STEAM education:

- **Science:** Thermodynamics, biology, meteorology, human physiology.
- **Technology & Engineering:** Use of sensors, data logging, and microcontrollers.
- **Arts:** Visual communication, storytelling, and creative climate messaging.
- **Mathematics:** Data analysis, graphing, relationships between variables.

By linking these fields, students see how scientific concepts have relevance.

7.3 Summary

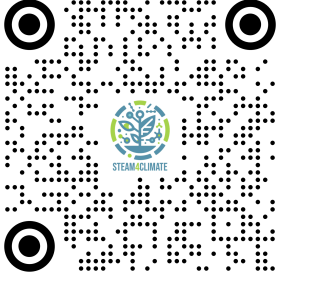
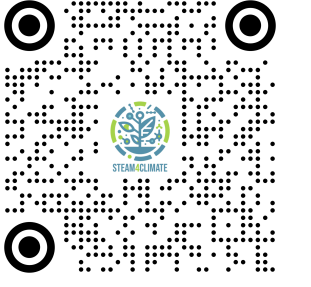
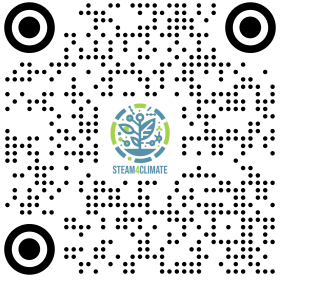
Through this project, students learned how temperature and humidity jointly determine the body's cooling efficiency, and why this relationship becomes increasingly important in a warming world.

They gained practical experience in measuring, analyzing, and interpreting real-world data, while also reflecting on the health, environmental, and social dimensions of climate change.

8. Extensions

This project opens the door to a variety of **extensions and deeper explorations** that connect scientific inquiry with creativity, data analysis, and community engagement.

Teachers are encouraged to adapt these ideas to suit classroom resources, student interests, and local climate conditions.

STEAM4Climate Online Webinar https://www.youtube.com/watch?v=MKNFSOJapi4	 A square QR code with a black and white pixelated pattern. In the center, there is a circular logo for STEAM4Climate, which features a stylized plant and the text 'STEAM4CLIMATE'.
STEAM4Climate Interviews – Science Teacher https://www.youtube.com/watch?v=WM5ZyGT6Is8	 A square QR code with a black and white pixelated pattern. In the center, there is a circular logo for STEAM4Climate, which features a stylized plant and the text 'STEAM4CLIMATE'.
STEAM4Climate Simulation of Wet Bulb Temperature https://iludis.de/wetBulbTemp/index.html	 A square QR code with a black and white pixelated pattern. In the center, there is a circular logo for STEAM4Climate, which features a stylized plant and the text 'STEAM4CLIMATE'.