

Hazard Literacy Center

Hazard Literacy Education Program

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Why Are Cities Hotter at Night?: Understanding the Urban Heat Island Effect through Radiation and Thermal Equilibrium



1. Program Overview

This program is a hazard literacy–based educational program aligned with the "Disasters and Safety" domain of the 2022 Revised Korean National Science Curriculum for Grade 9. It is designed to help students understand heatwaves not simply as periods of high temperature, but as climate-related hazards intensified by the structural and physical characteristics of urban environments. In particular, students explore the urban heat island (UHI) effect, in which artificial surfaces such as asphalt and concrete absorb, store, and release heat, causing cities to remain warmer than surrounding areas. Using the Predict–Observe–Explain (POE) model, students investigate the guiding question, "Why are cities hotter at night?" They predict temperature differences between urban and suburban areas, measure temperature changes using experimental models, and analyze the results through graphs. Based on their observations, students explain how heat absorption and release, heat storage, evaporative cooling, and spatial structure contribute to urban heat islands. Finally, they connect their experimental findings with local data to examine how green space, building density, and land use influence heatwave risk, providing a scientific foundation for the subsequent heatwave response campaign (PBL).

Grade Level	Grades 9	Instructional Methods	Lecture, Experiment
Learning Environment	Science Lab	Duration	90 minutes (45 minutes × 2 class periods)
Required Materials	Temperature sensors, heat source, identical containers, model walls, sand, water, timer		

2. Learning Objectives (Hazards Literacy Framework)

① Students will be able to compare temperature differences between urban and suburban areas and scientifically explain the causes of the urban heat island effect.

② Students will be able to measure temperature changes over time through an experiment modeling urban and suburban environments, represent the results in graphs, and interpret the urban heat island effect based on scientific evidence.

③ Students will be able to analyze why heatwave risks vary across different areas by integrating experimental results with local data, and assess and explain heatwave risks based on scientific evidence.

Learning Objectives	Knowledge & Understanding		Reasoning & Skills					Values & Attitudes			Psychology & Emotion			Behavioral & Practical Enagement		
	A1	A2	B1	B2	B3	B4	B5	C1	C2	C3	D1	D2	D3	E1	E2	E3
Objective ①	O	O	O	O												
Objective ②				O	O		O									
Objective ③								O	O		O					

3. Key Concpets

· Heatwaves

· Urban heat island effect

· Radiation, thermal equilibrium, and heat absorption and release

· Heat storage

· Interpretation of time–temperature graphs

4. Program Sequence

Learning Activities	
Introduction	·Watch a news clip or video introducing the urban heat island effect. ·Ask the guiding question: "Why are cities hotter at night than suburban areas?" ·Examine data showing temperature differences between urban and suburban areas and identify the problem of urban heatwaves.
Inquiry 1	·Predict temperature changes in models of urban and suburban environments. ·Predict which model will heat up faster and cool down more slowly. ·Explain the reasoning behind the predictions in terms of radiation, heat absorption, and surface properties.
Inquiry 2	·Heat the urban and suburban models under the same experimental conditions. ·Record temperature changes over time and represent the data in a graph.
Inquiry 3	·Explain the causes of the urban heat island effect based on the experiment ·Relate differences in heat absorption, release, and storage to the urban heat island ·Analyze local data and discuss the characteristics of areas with higher heatwave
Conclusion	·Summarize scientifically why temperature differences occur between urban and suburban areas. ·Present and share the causes of areas being particularly vulnerable to heatwaves.

5. Theoretical Background and Activity Design for Disaster Education

Heatwaves are a major climate-related hazard whose frequency and duration are increasing due to climate change. In urban areas, asphalt and concrete absorb and store solar heat, while dense buildings and limited green space reduce heat dissipation and evaporative cooling. These factors contribute to the urban heat island (UHI) effect, which can limit nighttime cooling and increase heat-related health risks.

This program uses the Predict–Observe–Explain (POE) model to help students investigate the UHI effect through experiments. Using urban and suburban models, students measure temperature changes during heating and cooling and construct time–temperature graphs. They examine how heat absorption and release, heat storage, and evaporative cooling contribute to temperature differences.

Students then connect their experimental findings with local data to examine how heatwave risks vary across areas. By using scientific evidence to explain and assess these risks, students develop hazard literacy and understand heatwaves as hazards shaped by both urban environments and human activities.

6. Instructional Considerations

Students often explain the urban heat island effect in terms of a single cause, such as buildings or dark asphalt. Teachers should emphasize that it results from multiple interacting factors, including heat absorption and storage, reduced green space and evaporative cooling, and building density. They should also clarify that the urban and suburban models used in the experiment are simplified representations of real environments.

In the POE activities, the focus should be on students' reasoning rather than whether their predictions are correct. After the experiment, students should use time–temperature graphs to compare their initial ideas with the results and reflect on how their explanations have changed. They should also connect the findings to local heatwave risks, considering factors such as green space, building density, and vulnerable populations. Through this process, students can develop hazard literacy by interpreting disaster risks based on scientific evidence.

7. References

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- Ministry of Education. (2022). 2022 Revised Science Curriculum. Ministry of Education.
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Why Are Cities Hotter at Night?: Understanding the Urban Heat Island Effect through Radiation and Thermal Equilibrium

Theme	Understanding the Urban Heat Island Effect through Radiation and Thermal Equilibrium
What Will We Learn?	① Students will be able to compare temperature differences between urban and suburban areas and scientifically explain the causes of the urban heat island effect. ② Students will be able to measure temperature changes over time through an experiment modeling urban and suburban environments, represent the results in graphs, and interpret the urban heat island effect based on scientific evidence. ③ Students will be able to analyze why heatwave risks vary across different areas by integrating experimental results with local data, and assess and explain heatwave risks based on scientific evidence.

1 Let's Predict

"Why Are Cities Hotter at Night Than Suburban Areas?"

• Watch a video about the urban heat island effect and look at temperature data from urban and suburban areas during a heatwave. Then, predict which area will heat up faster and cool down more slowly.

• Explain the reason for your prediction by connecting it to radiation, heat absorption, and surface properties.

	Urban Model (Sand)	Suburban Model (Water)
Which will heat up faster?		
Which will cool down more slowly?		

2 Experiment

Objectives Measure and compare temperature changes while heating and cooling the urban (sand) and suburban (forest) models under the same conditions.

Materials Temperature sensors, heat source, two identical containers, sand, water, timer

Procedure

① Prepare an urban model in one container and a suburban model in the other.

② Heat both models with the same heat source for a set period of time and measure their temperatures.

③ Turn off the heat source and measure the temperature changes as the models cool down.

Observation Table (Temperature Changes Over Time)

Time	Urban Model Temperature(℃)	Suburban Model Temperature(℃)
Heat 0 min		
Heat 10 min		
Heat 20 min		
Cool 10 min		
Cool 20 min		

3 Results

• Use the time–temperature graph to discuss the differences in heating and cooling rates between the urban and suburban models.

•Explain why the urban heat island effect occurs using the concepts of heat absorption and release through radiation and heat storage.

• Using the concept of evaporative cooling, explain why the suburban (water) model cools faster than the urban (sand) model.

4 Analyzing with Local Data

• Predict which areas in your school or neighborhood are likely to have higher or lower heatwave risk, and explain your reasoning based on factors such as green space, building density, and land use.

• Identify who may be particularly vulnerable to heatwaves and explain why they are at greater risk.

5 Reflection

① What was different between my prediction and the actual result?

② How do today's learned principles explain the urban heat island effect?

③ How can our school or community mitigate heatwave risks?