urban science

URBAN SCIENCE.
ENGAGING SCIENCE,
CREATING SUSTAINABLE CITIES

LEARNING MODULES

Co-funded by the Erasmus+ Programme of the European Union

HEATWAVES

Learning module
from the series SDG challenges in my city

Developed in the project
Urban Science
Engaging science, creating sustainable cities
co-funded by the Erasmus+ Programme of the European Union.

This module was created and first piloted by teacher members of the Hungarian Research Teachers' Association.

WILD AWAKE
CREDA ONLUS CENTRO RICERCA EDUCAZIONE DOCUMENTAZIONE AMBIENTALE
Bérenu Vides skola
KUTOSZ
GRID WARSZAWA | In partnership with UN Environment
ecosystem europe

URBAN SCIENCE.
ENGAGING SCIENCE,
CREATING SUSTAINABLE CITIES
LEARNING MODULES

Co-funded by the Erasmus+ Programme of the European Union

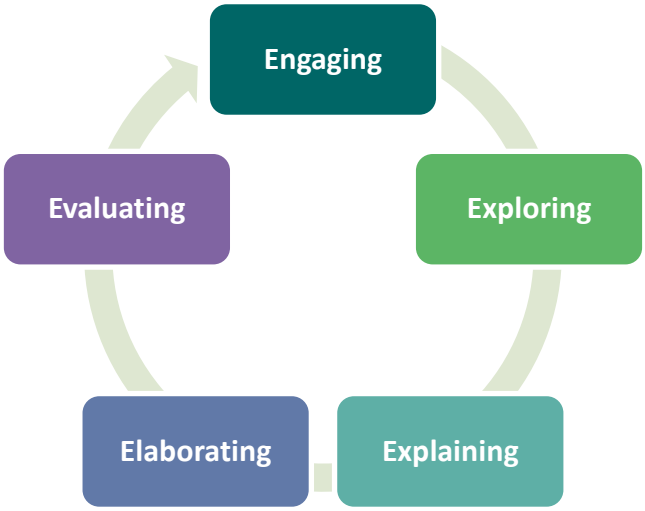
LEARNING MODULE

HEATWAVES

"The simple hands-on ativities in this module help students connect different science content learnt in different school subjects. Moreover, it brings those contents alive, making connections to real life experiences."

(Zsuzsa, science teacher from Hungary)

Activities in this module are organised around the 5E instructional model of inquiry-based learning.



Challenges linked to Sustainable Development Goals

- Strong links to SDG **3**: Good health and well-being, SDG **9**: Industry, innovation and infrastructure, SDG **10**: Reduced inequalities, SDG **11**: Sustainable cities and communities, SDG **13**: Climate action

Co-funded by the Erasmus+ Programme of the European Union

This module can be used individually or within the Storyline introduced by the module Back to the Future: Climate Change.

The scores for gamification are suggestions that teachers may modify according to their preferred pedagogical scenarios.

Introduction

Heatwaves do not equally effect city population. Those who cannot afford to live in the greenbelt or have air conditioning or even ventilators suffer more. At the same time, heatwaves will occur more often due to climate change.

How do heatwaves effect cities? What temperatures can be measured at canicular days in different parts of the cities? How can heatwaves become more tolerable?

Students explore these during a Storyline game.

Learning objectives

- raising students' attention to social inequities
- practicing empathy
- establish an understanding of radiation and heat energy
- empowering systems thinking
- deepening the understanding of the concepts of energy (enthalpy)
- learning about the urban heat island effect and the cooling effect of urban vegetation
- understanding the basic science behind the cooling effects of water and vegetation
- developing communication inquiry competences: forming evidence-based statements and expressing opinions, communicating results
- encouraging students to establish their own point of views based on scientific evidence and knowledge
- using argumentation to discuss the topic

Learning outcomes

- students understand the concepts of energy and radiation
- students deepen their knowledge about urban ecosystems
- students gain knowledge about closed systems
- students develop self-efficacy in experiments
- students practice working with scientific data
- students practice presenting and communicating their ideas

- students develop responsibility towards their environment
- students practice empathy
- students experience consensus-seeking and evidence-based decision-making in a model experiment
- students practice arfgumentation

Time needed to implement the Learning Module

135 minutes (3 x 45 minutes)

Activities in detail

(according to the 5E model)

Engaging

Introduction:

We are still in city S. (Any city name can be used, optionally also the real name of the city where the school is located.) *If your teams work well during this module, your city can take more steps towards being sustainable. If your teams fail; everything will stay as it was in the beginning of this module.*

(Teams can be the same throughout the whole Urban Science learning journey: in this case, individual points in this game's parts add to those team points. If this module is applied separately, districts will represent teams and individual points in districts will add to team points.)

Story:

We are in the city shown in the map. Now we have an exceptionally hot summer day. Take your role cards and close your eyes. Imagine where you are, what you do and how you feel. Say a sentence to the others. – 5 minutes

Students look at heat camera recordings and share their own experiences in teams. Teams report back to the class. – 5 minutes

Examples from Budapest:

https://index.hu/techtud/2019/06/16/hoseg_hokamera_zoldfelulet/

Teachers are encouraged to use local or regional examples if available.

Exploring

Look at the factsheet and the city map. Describe the microclimate in your home and workplace area. – 5 minutes

Resource example:

https://commons.wikimedia.org/wiki/File:Urban_heat_island_(Celsius).png

Story:
It is already hot and the National Forecast has just announced that another heatwave is coming. This time, heat records can be broken.

Look for people in the surrounding area, share and discuss, then try to make your point. – 5 minutes

Explaining

Story:
To better see what we can do, lets' discover the science beyond. You'll work in district teams, and those who have the most individual points so far will become team leaders for the research. Each of you and through that each team can collect more points.

Working in teams, make the two experiments, then note your observations and results: – 15 minutes

Materials

- Measuring cup
- Water
- Rubbing alcohol
- Cooking oil, such as olive oil or other
- Plastic plates, indisposable (4)
- Paper towels (12)
- Clear tape
- Ballpoint pen
- Infrared thermometer
- Stopwatch
- Small fan; if you do not have a small fan, you will need an extra plate.
- Lab notebook
- Graph paper

Procedure

Experiment (1)

1. Fill a measuring cup with tap water and allow it to come to room temperature.
    a. The rubbing alcohol and the oil should also be at room temperature.

   b. This step is just to ensure that the liquids are at the same temperature at the start of the experiment.

2. Place four indisposable plastic plates, with the up sides down, on a work surface.
   a. Use a waterproof surface (such as tile or laminate) since you will be using alcohol that could damage wood finish.
3. Fold each paper towel in half twice, so that each has four layers.
4. Place a folded paper towel on top of each plate.
   a. The plates keep the towels from being in contact with the work surface, which would affect their temperature. You could also use Styrofoam™ or other insulating material.
5. Tape the edges of the paper towels to the plates.
6. Label the paper towels 1–4.
   a. In the next step, the paper towels will be treated as follows:
      a. 1: no liquid
      b. 2: water
      c. 3: rubbing alcohol
      d. 4: oil
7. Start the stopwatch.
8. Take the temperature of the paper towels with the infrared thermometer.
   a. Take three readings of each paper towel.
   b. Keep the direction and distance between the thermometer and each plate the same.
   c. Record the temperatures and times in a data table in your lab notebook.
9. Pour water on paper towel #2, just enough to wet it.
10. Pour rubbing alcohol on paper towel #3, just enough to wet it.
11. Pour oil on paper towel #4, just enough to wet it.
12. Take the temperature of each paper towel, and record the temperature and time in your lab notebook.
13. Repeat the temperature readings three more times, at 2-minute intervals.
14. Which paper towel has the lowest temperature? What was the largest temperature difference between two paper towels that you noted? Record all observations in your lab notebook.

15. Repeat steps 1-14 two more times, with fresh paper towels, but you can rinse and reuse the plates. Average the results in your final report.
16. Repeat steps 1-15 three more times, only for these trials, with the fan gently blowing over the paper towels. If you do not have a fan, use a paper plate as a fan. Your helper can fan as you take and record the temperature at 2-minute intervals. Did the fan change the results? Why?

Experiment (2)

1. Mark a small spot on your arm with a ballpoint pen.
2. Measure the temperature of the skin on your forearm near the pen mark.
    a. As in the section before, take two more readings and average them.
3. Pour some room-temperature water on your arm.
4. Take the temperature of your skin near the mark. Record all data in your lab notebook.
5. Take a temperature reading every minute until your arm dries.
6. Repeat steps 1-5 two more times.
7. Now repeat steps 1-6 of this section three times, this time using the fan or helper with the paper plate to blow air on your arm. Average all the results.
8. Graph your results.
9. What temperature change did you see?
10. Repeat steps 1-9 of this section using rubbing alcohol. What is the difference in the temperatures between water and alcohol?

Working in teams, collect names of scientific phenomena and evidence about them to explain why green areas have a cooling effects, whereas concrete and stone have a heating effect in cities. – 10 minutes

Extra individual points for next lessons:

Home experiments

- same experiments using other materials (nail polish remover, after shave, cooking oil, etc) – up to 10 individual points each
- same experiments recording the time during which a flat sheet of paper and a spitball made of the same size of paper, both soaked in water previously, dries – up to 10 individual points

- modelling a swamp cooler in the house – up to 20 individual points
- designing a research project with measurable variables – up to 20 individual points
- carrying out a research project with measurable variables – up to 20 individual points

Elaborating

Story:

You remember that last time we were in city S on a day with a heat spell. Remember how did you feel?

Today we are working towards making city S more sustainable. The better you work, the more your city can achieve. If you can't progress, the city stays the same: still in the danger zone from so many aspects!

Each district will have a leading designer today. Those who gained the most individual points in each district, will be the leading designers.

Students take a walk outside and measure surface temperatures. – 15 minutes

Students work with their results – 25 minutes.
Instructions:

Based on your result, after consulting the press cuttings, re-design your district.
Focus on the following questions:

- What changes will you make?
- How can you improve living conditions and well-being for residents there?
- What green surfaces could you imagine?
- What changes would they make in temperature?

Prepare an info-board with your design ideas, explaining the proposed measure / change, the desired effect and the science evidence behind. Share your info boards with the teacher.

Extra individual points for next lessons:

- preparing posters or infographics – up to 20 individual points each

Story:

Co-funded by the Erasmus+ Programme of the European Union

We continue working for city S. Last time you progressed well for working towards its sustainability. We will have new officers for the next phase. Districts that earned the most team points will present their findings first (presentations by team leaders). The municipality them will decide how much financial support districts can get for their projects.

Evaluating

Teams preparing for presentation – 5 minutes
Teams reporting back to class – 20 minutes
Voting for other resources: districts give cards with percentage of available budget, then summing up by districts how much they could earn. – 5 minutes

Story:

As we all worked towards improving the life of this city, we have

Discussing science points: listing and clustering phenomena used for problem-solving – 5 minutes

Story:
Based on our work, city S will stay the same / take a small / big step towards sustainability. Now teams, based on their results may decide what steps their city can take. What will this be?
(Here the teams based on how many points they gained, may list 1 up to 5 steps.) – 5 minutes

Teams evaluate their learning by using grid – 5 minutes

Story continues if another module will be introduced to the group.

Resources:

Heat islands:

https://jarokelok.blog.hu/2019/08/02/viragos_veszprem_avagy_varosi_zold_strategiak_a_kerteszetben (in Hungarian)
https://index.hu/techtud/2019/06/16/hoseg_hokamera_zoldfelulet/ (in Hungarian)
https://www.actionbioscience.org/environment/voogt.html?print
https://commons.wikimedia.org/wiki/File:Urban_heat_island_(Celsius).png

Experiments:

https://www.scientificamerican.com/article/chilling-science-evaporative-cooling-with-liquids/
Science Buddies Staff. (2017, July 28). *Just Keep Cool—How Evaporation Affects Heating and Cooling.* Retrieved from https://www.sciencebuddies.org/science-fair-projects/project-ideas/Chem_p071/chemistry/-how-evaporation-affects-heating-and-cooling
https://science.wonderhowto.com/how-to/demonstrate-cooling-by-evaporation-176573/
https://orbit.dtu.dk/ws/files/148573376/Untitled.pdf

Press cuttings:

https://www.levego.hu/kapcsolodo-anyagok/fogalommagyarazat-a-varosi-zoldfeluletek-es-zoldteruletek/ (in Hungarian)
https://www.szephazak.hu/kert-tippek/a-zoldterulet-fogalma/701/ (in Hungarian)
https://www.szephazak.hu/kert-tippek/a-zold-varos-alapelvei/708/ (in Hungarian)
https://piacesprofit.hu/klimablog/naponta-kiderul-a-varosi-beton-maga-a-katasztrofa/ (in Hungarian)
https://www.theguardian.com/sustainable-business/2017/feb/21/urban-heat-islands-cooling-things-down-with-trees-green-roads-and-fewer-cars
https://www.epa.gov/green-infrastructure/reduce-urban-heat-island-effect

Scientific papers/ further reading:

http://nimbus.elte.hu/tanszek/docs/BSc/2015/SzaboBeata_2015.pdf (in Hungarian)
https://www.sciencedirect.com/science/article/pii/S2405844019300702
https://link.springer.com/article/10.1007/s40808-018-0456-7
http://www.lowcarbonlivingcrc.com.au/sites/all/files/publications_file_attachments/rp2024_guide_to_urban_cooling_strategies_2017_web.pdf
https://www.epa.gov/sites/production/files/2017-05/documents/reducing_urban_heat_islands_ch_1.pdf

Other resources:

Role cards:

Each role can appear in each district as listed below.

Districts:

- greenbelt area with single-family detached houses
- housing estate with tower block apartments in mainly concrete surroundings
- downtown terraced houses in a popular (touristy) area
- semi-detached houses in a downtown area
- newly built suburban housing estate with some green spaces

Roles (examples):

- elderly woman living with her cat
- working mother with two schoolchildren
- middle-aged working father with small children
- old man living with her wife
- young single man living with a dog
- young single woman sharing a flat with friends
- middle-aged couple commuting to work in another city

Co-funded by the Erasmus+ Programme of the European Union

Table of points:

Activity	Individual point	Team point	Individual extra	Team extra
Sensible feedback on heat camera photos	1	Using science language: 1	Using facts: 1	Using scientific evidence: 1 Referring to scientific phenomenon or law: 1
Localising places on the map	1	If all are ready on time: 2 If >75% ready on time: 1 Otherwise: 0		If the sum of individual points exceeds 80% of the total achievable: 2
Describing microclimate	based on previous data, with proper estimations: 2 without proper (or with improper) estimations: 1 no sensible description: 0	If all are ready on time: 2 If >75% ready on time: 1 Otherwise: 0		If the sum of individual points exceeds 80% of the total achievable: 2
Making points in districts	1	Sum of individual points of team members If all are ready on time: 2 x the sum of individual points If >75% ready on time: 1 x the sum of individual points Otherwise: 0	For everyone in district teams that were: using scientific evidence: 1 referring to scientific phenomenon or law: 1	If the sum of individual points exceeds 80% of the total achievable: 2
Experiment 1	Proper work: 1 Data identified:1 Data organised: 1 Graph: 2 Data analysed: 2	Sum of individual points of team members If all are ready on time: 2 x the sum of individual points If >75% ready on time: 1 x	• with other materials (nail polish remover, after shave, cooking oil, etc) – 10 • record the time during which a flat	If the sum of individual extra points exceeds 75 % of the total achievable: 2x individual extras

	Explanation: 2 Cleanup:1 Overall: 10 (same points for everyone in the small group or the overall points are divided by the group members based on their contribution to the results in a way that the sum of individual points equals the team points)	the sum of individual points Otherwise: 0	sheet of paper and a spitball made of the same size of paper, both soaked in water previously, dries – 10 • modelling a swamp cooler in the house – 20 • designing a research project with measurable variables – 20 • carrying out a research project with measurable variables – 20	Otherwise sum of individual extras. In case the team sizes are different, the team extras from individual extras can be calculated in a way to eliminate disadvantages (e.g. sum of individual extras divided by the number of team members).
Experiment 2	Proper work: 1 Data identified:1 Data organised: 1 Graph: 2 Data analysed: 2 Explanation: 2 Cleanup:1 Overall: 10 (same points for everyone in the small group or the overall points are divided by the group members based on their contribution to the results in a way that the sum of individual points equals the team points)	Sum of individual points of team members If all are ready on time: 2 x the sum of individual points If >75% ready on time: 1 x the sum of individual points Otherwise: 0		

Measuring surface temperatures outside	data collected:5 data organised: 5 (same points for everyone in the small group or the overall points are divided by the group members based on their contribution to the results in a way that the sum of individual points equals the team points)	Sum of individual points of team members If all are ready on time: 2 x the sum of individual points If >75% ready on time: 1 x the sum of individual points Otherwise: 0	-	-
Re-designing district	using scientific evidence: 5 understanding phenomena: 3 applying science knowledge: 3 considering inclusion: 3 causality:3 presentation:3 Overall: 20 (same points for everyone in the team or the overall points are divided by the group members based on their contribution to the results in a way that the sum of individual points equals the team points)	Sum of individual points of team members If all are ready on time: 2 x the sum of individual points If >75% ready on time: 1 x the sum of individual points Otherwise: 0	preparing poster or infographics: max. 20	Sum of individual extras. In case the team sizes are different, the team extras from individual extras can be calculated in a way to eliminate disadvantages (e.g. sum of individual extras divided by the number of team members).

Co-funded by the Erasmus+ Programme of the European Union

Template for role-play character card

HEATWAVES CHARACTER CARD	Name:
	Age:
	Sex:
	Occupation:
	Bio/Details/Point of view:

HEATWAVES CHARACTER CARD	Name:
	Age:
	Sex:
	Occupation:
	Bio/Details/Point of view: