STÁTNÍ FOND ŽIVOTNÍHO PROSTŘEDÍ ČESKÉ REPUBLIKY

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A Cool Town

Abstract

It's a hot summer day, the temperatures have climbed high above 20 degrees, and an uncomfortable state of overheating is slowly engulfing the town. Can it be prevented? And how? This minilesson challenges students to cool down their town. Students are introduced to natural phenomena and laws that inspire people's design and implementation of measures to adapt to climate change in and out of urban areas. Students will understand that none of the laws and phenomena presented works in isolation but all are deeply interconnected. Nature should be viewed as a whole, not a set of separate independent parts.

Unit type and duration

The activities require a total of two 45-minute lessons. Activity 2 includes an experiment with a delay of several hours until results can be observed. It is thus recommended to start with the experiment and conclude it after completing the minilesson. The experiments included require a sunny weather, ideally during summer.

Target group

Lower secondary programmes, upper secondary programmes.

Context and cross-curricular links

Above all, the minilesson integrates the following subjects: Biology; Physics; and Mathematics.

Goals and outputs

Goals:
- Students learn about natural phenomena linked to climate change adaptation.
- Students understand that natural phenomena and laws do not work in isolation, they are all interrelated, and therefore, the nature should be viewed as a whole, rather than a set of separate independent parts.

Outputs:
- Students recommend climate change adaptation measures suitable for the community.

- Students develop their analogical and critical thinking, argumentative and discussion skills.

Outline of the activities

Activity 1: Brainstorming – introducing the topic
Duration: 20 minutes
Location: classroom
Materials: sticky notes, writing supplies

Activity description:
Start by inviting students to formulate their views on how the urban environment can be cooled down. You can write their views on the whiteboard. Alternatively, give a few sticky notes to each student, inviting them to consider their answers individually and then share them with the group.

Activity 2: Transpiration in plants
Duration: 30 minutes
Location: classroom
Materials: Each student will need: Two half-litre plastic cups or two 1.5–2l plastic bottles (transparent, not coloured), or two 0.7l jars (e.g. from pickled vegetables); (a knife for cutting the bottles;) a piece of cardboard; scissors; adhesive tape; a live fern stem (a twig of spruce, bush, ...); 0.4 l of water; internet access; Evapotranspirace.ppt teacher's presentation

Activity description:

INTRODUCTION: Do you know why plants need watering? Water is required for two processes in plants: (a) photosynthesis, in which water is split and (b) transpiration, whereby water is evaporated from the leaves, creating a pull in the plant's vascular tissue. The pull helps the plant feed its cells by sucking water, including nutrients, from the soil. Transpiration fuels the plant's metabolism, as it works like a solar pump. A single tree can evaporate hundreds of litres of water on a hot sunny day. The question is, how come trees actually help hold water in the soil? One of their important functions is to suck water from deep layers that would otherwise remain inaccessible to other organisms. Their roots also provide mechanical protection against water runoff, especially on slopes. Finally, their condense significant amounts of water before sunrise or in foggy conditions.

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Invite students to prepare an experiment exemplifying transpiration in plants on a live twig enclosed in two plastic cups or jars. In the remaining time, students review online sources to explore natural solutions for urban adaptation to climate change.

The experiment is prepared as follows: If you are using plastic bottles, cut them into two pieces at a height of 15 cm from the bottom part to provide a cup and a "hat" for the twig. Then fill the cup with water. Subsequently, cut out a round piece of cardboard so that it precisely covers the top part of the plastic cup/jar. In the centre of the cardboard, make a small opening to insert the twig's stem into the water. After pushing the twig through the cardboard, surround it with adhesive tape so that no water can evaporate through the opening into the top part of your cup/jar. Cover your twig with the other cup/jar and cover the joint with adhesive tape. Draw a line on the bottom container to indicate the current water level.

Now that everything's ready, proceed to the experiment proper. Place the containers with the twig inside under a lamp or in a sunny spot outside the window. Let them "work" for several hours or wait until the next day. The top container will contain drops of condensed water. Measure and record the difference in water level.

Then open a discussion and consider the following questions:
- Are there any differences between your results?
- What causes them provided everyone has a twig of the same species?
- Are there any differences between results when students have used different plant species?
- What is causing the difference – besides the fact of using different species?

To support the discussion, you can use the prepared presentation, either as it is or after adapting it to your needs. Other discussion questions based on the presentation:
- How do people make everyday use of evapotranspiration in plants? Imagine you're an architect building a house and you want to ensure a nice climate inside it. Can plants be of any help? If yes, how? – green roofs and facades, green interior walls – plants, mosses... humidify the air inside
- How would you change the land to hold more water? A diversified land with natural water basins, trees, hedges, soil covered with vegetation.
- What would happen if all trees suddenly disappeared from the Earth?
- Brainstorming – we don't know the answer, it's up to the students to use their fantasy.

Activity 3: The warming effect of surface albedo
Duration: 45 minutes

Location: in classroom or outdoors
Materials: Each student team will need: a desk lamp with a stronger bulb (10 W) or a sunny window, a black and a white mug, 1 infra-red thermometer, pen and paper to record the measurements or worksheets (Spreadsheet and Chart – albedo effect). When working on computers, present your data using the Excel albedo.xls spreadsheet), Albedo.ppt

Activity description:
The goal of this activity is to measure the warming time of two jars of different colours and to measure the temperature of diverse exterior surfaces. Students will find out how heat is absorbed depending on the colour of an object. Conduct your experiment as follows: Place two jars, a black one and a white one, in front of a switched-off lamp. Measure the current temperature of the jars. Switch the lamp on or expose the jars to sunlight. Measure and record any temperature change every minute for the next 15 minutes. Chart your results. On a warm and sunny day, you can distribute thermometers, go outside and invite students to measure the surface temperature of various inanimate objects – a façade, a pavement, a car, stones, sand. Students should notice their colour as well as temperature.
Proceed to presenting the results of the experiment. Each team presents its jar experiment results charted in the worksheet or Excel spreadsheet (Albedo.ppt). Invite students to share their measurements of outside surface temperatures.

Conclude the activity by opening a discussion based on the following questions:

- Think together about the likely effect of albedo on a town's climate on a hot sunny day. Where would you feel bad and where better?
- Recall the typical colour of Mediterranean houses (e.g. in Greece). Why are there places in and out of urban areas that are permanently warmer than others? What kind of strategy might help cool down urban areas? – painting roofs and façades white, making pavements and roads of more reflective materials than asphalt and concrete.
- Why is the heat island effect such a problem when we have things like air conditioning or swimming pools?

Activity 4: The cooling effect of plants
Duration: 45 minutes
Location: in classroom or outdoors
Materials: each pair of students will need an infra-red thermometer, a cup of water, a piece of cloth/tissue, a pen and paper for recording and charting temperature data, selected interior plants in case of working in the classroom – suitable for the entire class, Chladící efekt rostlin.ppt teacher's presentation.

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Activity description:

INTRODUCTION: Bathing or sweating are the best ways to cool down on a hot summer day. Water evaporates at temperatures above 0 °C. This process consumes energy, heat, resulting in local cooling. Plants cool their surroundings by evaporating water from their leaves during evapotranspiration. The sunnier a day, the warmer it is, the more the plant transpires (there must be enough water in the soil), and the higher the amount of thermal energy consumed. Reflect on the importance of plants in urban environments (you already know about albedo and transpiration). What are the cooling effects of lawns, bushes, individual trees, or a forest? Do bodies of water (like lakes, streams, rivers, seas) have the same cooling effects as trees or forests?

Lake: water only evaporates off the surface; tree: immense combined surface of all leaves, wind blowing through the canopy increases transpiration.

In the case of outside activity, students should take all the materials listed with them. Provide access to diverse surfaces such as asphalt, concrete, metal, glass, soil, sand, stones, grass, bushes, trees, or water. If you stay inside, there is no need to organise the classroom for the activity but you should bring some interior plants or make sure some are located nearby in the hallway.

During the activity, students will be measuring the temperature difference between their skin and various outside surfaces, both man-made and natural ones, including plants. Use infra-red thermometers to gauge the skin temperature of a selected student. Then use water to moisten the same spot on the skin and continue measuring. The temperature of the spot decreases, only to start climbing later on. Measure the temperature of the interior plant (for exterior activity, use the lawn in front of the school building, a bush, a tree canopy). Then measure the temperature of the adjacent road, buildings, cars, etc. Deduce the surface temperature of the tree from that of bare ground. This indicates how much vegetation can cool down its surrounding environment compared to bare ground (different types of vegetation exhibit different cooling capacities).

After experimenting and measuring, prepare your presentations by charting the recorded skin temperatures and present them to the class. Do the same with the cooling capacity of the vegetation.

Again, conclude the activity by opening a discussion based on the following questions:

- How would you possibly feel on a hot day in a town devoid of vegetation?
- Do you know a local area without vegetation? How do you feel there?
- What has a higher cooling capacity – a body of water or a forest?
- How can you use plants to cool down buildings or open urban spaces?
- What role do plants likely play in decreasing the greenhouse effect (warming)?
- Compare two interiors. Where would you rather work? Why?

Prerequisites and possible follow-up minilessons:

Possible follow-up activities can be drawn from the other minilessons, namely Climate Map or Wet, Not Flooded.
Climate Map – Students create a map focusing on sources of climate risk as well as existing adaptation and mitigation measures. Based on a set of orientation questions, they explore their community in depth and draw links between local topics and contexts. They map their knowledge using a unique set of graphical symbols. The resulting map describes the climate situation of the community. The minilesson helps students realise that climate problems exist in their community, too, and find out how it is doing in terms of climate change.
Wet, Not Flooded: In this minilesson, students conduct experiments to explore the ability of humus to absorb and hold water like a sponge. Students test how much water different soil samples can suck in and explore natural solutions for urban adaptation to climate change. Furthermore, students use different natural materials in an attempt to hold as much water as possible in a model piece of land – a pile of sand/soil.

Integrating the place and the community in the minilesson

Students spend a great part of the minilesson outside in the local community studying the effect of heat on urban areas and life in them. While the minilesson is not designed to promote cooperation with the community, it can be extended to include follow-up activities that do integrate such cooperation.

Application of PBL principles and the PBL Rung attained

Principles:
On-site learning – As learning steps outside the school, the community and its surroundings become the classroom.
Learning about the place – In the minilesson, students only begin to discover the possibilities of cooling their town. Thus, the principle of learning about the place is not fully applied. That will be the case in the follow-up minilesson, Climate Map, where students use their knowledge and skills to design local adaptation and mitigation measures.
Learning through the place – Students learn about the implications of the global problem of climate change by examining the impact on their community and its preparedness for climate change.
Learning for the place – The minilesson serves as an introduction to tackling the effects of heat and draught on one's place. Thus, the principle is not applied here. In follow-up

activities of the Climate Map minilesson, students can apply what they have learned in this minilesson to design, for example, a local adaptation measure as a real, tangible and useful contribution to quality of life and environmental quality in their community.

Place attachment – While the minilesson is not designed to promote place attachment, it helps students get to know different local places and reflect on the ways their community is prepared for the impacts of climate change.

Adapting to local situation – The minilesson responds to local conditions and needs, and the learning process is adapted to them. Focusing on the local impacts of heat and draught, students learn about the specifics of their community.

Personal relevance – Students find the learning process personally relevant, being able to see how it relates to their own lives. Students realise the impacts on their own lives. In discussions, students reflect on the ways they personally, together with others, can help prevent those risks.

Active student involvement/participation – Students get actively involved in the minilesson by conducting experiments individually or in teams with fellow students.

Community partnership – While the minilesson is not designed to promote community partnership, it can be extended to include such activities of the follow-up minilesson, Climate Map, that are based on cooperation with the community.

Interdisciplinarity – The entire topic of climate change is interdisciplinary and cross-curricular. The minilesson integrates the subjects of Biology; Physics; Mathematics; Civics education; and Arts.

Full-fledged teaching tool – The minilesson integrates different areas across the curriculum (see above).

Cooperation – Learning occurs in the context of group work, with teamwork-based assignments.

Place-Based Learning Ladder (the rung attained by the minilesson is in bold):

Rung 1

Lessons are adapted by adding local examples to existing teaching units.

Rung 2

Lessons are designed to include direct experiences of the place (or direct experiences of the place are added to existing teaching units).

Rung 3

Teaching unit is designed to use the advantages of the place and form a community partnership.

Rung 4

Integrated teaching unit based on PBL that involves service learning and a strong community partnership.