URBAN SCIENCE.
ENGAGING SCIENCE,
CREATING SUSTAINABLE CITIES
LEARNING MODULES

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

ATTRACTION TO SHINE: POLARIZED LIGHT

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.

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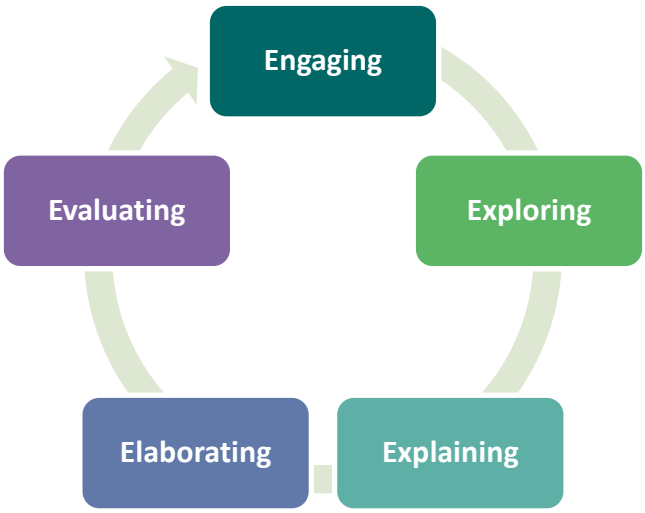
LEARNING MODULE

ATTRACTION TO SHINE: POLARIZED LIGHT

"You may think that the built environment of the city is not the place to do outdoor activities with students to study ecology. With this module, I could do it in the middle of Budapest."

(Zoltán, science teacher from Hungary)

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



Acknowledgement: the outdoor activities in this module are developed, researched and published by György Kriska, Zsolt Karkus and Anita Dr. Kriskáné Gánóczy

Challenges linked to Sustainable Development Goals

- Strong links to SDG **6**: Clean water and sanitation, SDG **9**: Industry, innovation and infrastructure, SDG **11**: Sustainable cities and communities,
- Links to SDG **12**: Responsible consumption and production, SDG **15**: Life on land

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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

The concept of light pollution is primarily connected with the night lights images of cities. Besides these impressive decorations though, dark but shiny surfaces can also act as ecological traps.

Atmospheric reflection of upward night illumination by artificial lights on the ground surface was initially considered a harmless phenomenon, but with the spread of public lighting, artificial light has also been shown to have a detrimental effect on wildlife, such as the mass destruction of certain insects and the food chains and habitats can cause deterioration.

However, besides this, due to a phenomenon unseen but observable for the human eye called light polarization, some dark and glittering surfaces (such as asphalt roads, black car bodies, black gravestones, glass wall buildings, oil ponds, horizontal solar panels, black agricultural plastic films) can attract and kill water insects in masse. This is due to the positive polarotaxis (attraction to horizontally polar light) of water insects and the reflection light polarization caused by light reflecting dark surfaces. More than 300 aquatic insect species are known to have positive polarotaxis because of searching for aquatic habitats on the water surface based on horizontal polarization of reflected light. Thus, each of these insects is affected by the widespread ecological trap, known as polar light pollution, that artificially polarizing artificial surfaces that are highly and horizontally imitate and attract these insects, which lay their eggs that later die because of dehydration, thus weakening the survival chances of the insect population and having an effect (as a consequence) on urban ecosystems.

In this module, students make inquiries about polarotaxis. It is worth getting informed about which species are affected and when their reproduction period is due. For example, in Hungary (and in many other European country, a net-spinning caddisfly, Hydropsyche pellucidula (https://www.naturespot.org.uk/species/hydropsyche-pellucidula) is attracted to polarized light and can be observed in masses along riverside buildings in May–June.

The module works best if there are either riverside buildings or open-air car parking lots or cemeteries or asphalt surfaces are available, preferable in May or June. However, with other species (there are more than 300 listed in literature!) different settings with massive, shiny dark surfaces can be also options.

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Learning objectives

- raising students' attention to light pollution
- establish an understanding of light characteristics and polarization
- learning about food networks and understanding some basic principles of ecology developing science competences: data collection, data processing, comparing data, causality, observation of phenomena
- developing cognitive skills in social inquiry competences: problem-solving, critical thinking, creativity
- 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 qualities of light and polarized light
- students deepen their knowledge about urban ecosystems
- students gain knowledge about light pollution
- students develop self-efficacy in outdoor observation and data procession
- students practice working with scientific data
- students practice presenting and communicating their ideas
- students develop responsibility towards their environment

Time needed to implement the Learning Module

90 minutes (2x45 minutes) + at least 30 minutes observation at dusk

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.)

Humans are naturally attracted to glossy and shiny objects. Probably that is one reason why there were so many glass surfaces on buildings in 2020s. Do you think it is good to have glass surfaces on buildings?
Students collect pro and con ideas about glass surfaces of buildings: think-pair-share exercise – 5 minutes

Exploring

There is profound difference in how animals and humans see these objects. That's what we will discover here.

There is a feature of light that many animals perceive, but which is invisible to the human eye: the polarization of light. Probably in mammals and humans the ability to see polarization did not develop during evolution as because of the advanced brain there was no need for it. But the polarization of light carries a lot of useful information, and human beings to overcome their biological deficiencies developed technical tools with which light polarization is detectable and measurable. The simplest tool to make the polarization of light visible for the human eye is a linear polarizing filter. This filter reduces the glare and the strong reflections of non-metallic reflecting surfaces, resulting in clearer and more intense colors on the surface being tested.

Students take a tour to examine polaried light with linear polarizing filters. Before the tour, they get convinced that the phenomenon exists: they examine polarized light using their smartphones (or a screen) with a white background, transparent plastic objects and a pair of 3D glasses. – 5 minutes
Examples:

https://hackaday.com/2014/01/07/homemade-polariscope-is-super-easy-to-make/

https://digital-photography-school.com/make-funky-images-plastic-objects-polarizing-filter/

They can look around using the same equipment – 5 minutes
Example:

https://www.youtube.com/watch?v=Z9vvFxVlUhY

Then students prepare polarizer filters – 5 minutes

Example: https://www.youtube.com/watch?v=ObdcScUEICM

Then students take a tour in the city and observe polarized light. – 25 minutes

Discussion of outdoor observation and observation sheets – 5 minutes

The activity continues at dusk.

Students meet at a choosen building walking around it, participants record their insect observations: for example, at what levels and at what intensity the swarming takes place, how insects behave on the glass window. If possible (accessible) it is worth observing the phenomenon from inside of the building (the other side of the glass windows) and make notes on some indididuals on the outer and inner window surfaces. They can use the worksheet too to observe the polirizing object and the possible swarming of caddisflies. Students also observe other species if possible. – 30 minutes extra time

Explaining

Students work in teams of 4 and discuss their individual observation sheets. They present their results in a graphic form with explanations. – 10 minutes
Discussion – 5 minutes
If observed, answer the question:
How can one explain that the presence of a larger, not really insectivorous species of magpies at the building has become more dominant than fowlpoxes, mallards and house sparrows?
If not observed, discussing other phenomena from related Biology, e.g. the zebra pattern.

Elaborating

Argumentation game:
A new architect designs a shiny glass building to the riverside // The municipality decides to place solar panels to the buildings by the riverside. Using scientific evidence and argumentation, students discuss in a fishbowl setting whether they can support the idea. – 10 minutes
Tip:
With a beginner group, use the repetitive technique:
The discussing partners have an object (e.g. a pencil) in the hand. They give their point. Then they pass on the pencil to the other, who repeats their point. If it was correct, according to their counterpart, they return the object and may start setting their point. If not, they continue until the other accepts the recapitulation, and only then can they move forward with theirs. This exercise is longer but improves listening skills and moves from quarrels towards debates and argumentation.

Fishbowl activity:
Students discuss about polarized light pollution and how undesirable effects could be minimised. – 10 minutes

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Evaluating

Using thermometer technique, students give their points about the necessity of possibly polarizing elements in cities – 5 minutes

Using self-evaluation form students assess their learning – 5 minutes

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Resources:

https://en.wikipedia.org/wiki/Polarizing_filter_(photography)
http://www.eltereader.hu/media/2016/09/Kriska_Polaros-feny_ajanlo_READER.pdf
https://arago.elte.hu/sites/default/files/VerticalGlassPol_AO.pdf
https://books.google.hu/books?id=5g0fBQAAQBAJ&pg=PA451&lpg=PA451&dq=polarotaxis+cities+insects&source=bl&ots=mZzDCz9xXZ&sig=ACfU3U1CmoLKGW-Pg4yD7qhk70rNBrz94w&hl=fr&sa=X&ved=2ahUKEwi_xN_q6ankAhXDpIsKHbJoDlwQ6AEwGnoECAkQAQ#v=onepage&q=polarotaxis%20cities%20insects&f=false
https://link.springer.com/article/10.1007%2Fs00114-008-0345-4
http://bszm.elte.hu/Kriska_Karkus_konyv.pdf (pp 314-32, in Hungarian)

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<table>
<tr><th colspan="5">Polarization worksheet</th></tr>
<tr><td colspan="5">Observations about polarizing light</td></tr>
<tr><td>1.</td><td colspan="4">Use a linear polar filter to determine how much of the building is polarizing the reflected light and with what plane of vibration.</td></tr>
<tr><td></td><td colspan="2">(photo or drawing)</td><td colspan="2">(description)</td></tr>
<tr><td>2.</td><td colspan="4">Rank each building element based on its polarizing ability. Mark polarizing reflective elements in an ascending order from 1 to 4</td></tr>
<tr><td></td><td>Bright coloured, bright facade surface</td><td>Dark coloured, bright facade surface</td><td>Window with white ribbon curtain</td><td>Dark window surface with no curtain drawn</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="5">Observing caddisflies outside and inside the building</td></tr>
<tr><td>3.</td><td colspan="4">How do groups of caddisflies behave?</td></tr>
<tr><td></td><td colspan="2">(photo or drawing)</td><td colspan="2">(description)</td></tr>
<tr><td>4.</td><td colspan="4">Approximately, how many individuals are there in the groups caddisflies are forming in front of the windows of the building?</td></tr>
<tr><td></td><td colspan="2">(photo or drawing)</td><td colspan="2">(description)</td></tr>
</table>

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<table>
<tr><td rowspan="3">5.</td><td colspan="4">Observe 4 behaviours.</td></tr>
<tr><td colspan="2">(photo or drawing)</td><td colspan="2">(description)</td></tr>
<tr><td>landing on the glass</td><td>mating</td><td>walking on the glass surface</td><td>flying off the glass surface</td></tr>
<tr><td rowspan="6">6.</td><td colspan="4">Using your smartphone zoom or binoculars count the number of individuals on 10-10, light and dark coloured facade elements of the same surface.</td></tr>
<tr><td colspan="2">(photo or drawing)</td><td colspan="2">(description)</td></tr>
<tr><td colspan="4">DARK FACADE ELEMENTS – overall individuals:</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="4">LIGHT COLOURED FACADE ELEMENTS – overall individuals:</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">7.</td><td colspan="4">Characterize the behaviour of the caddisflies entering the building at open sliding windows!</td></tr>
<tr><td colspan="2">(photo or drawing)</td><td colspan="2">(description)</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td rowspan="3">8.</td><td colspan="4">What are the effects resulting in mass destruction of trapped insects by the open tilt windows?</td></tr>
<tr><td colspan="2">(photo or drawing)</td><td colspan="2">(description)</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td rowspan="3">9.</td><td colspan="4">What measures can be taken to effectively reduce the number of caddisflies entering the building?</td></tr>
<tr><td colspan="2">(photo or drawing)</td><td colspan="2">(description)</td></tr>
<tr><td colspan="4"></td></tr>
</table>

Observations about food networks		
10.	*By studying the walls of the building, determine what / how many different spider species, with which catching strategies hunt the caddisflies outside the building?*	
	(photo or drawing)	(description)
11.	*By studying the walls of the building, determine what / how many different bird species, with which catching strategies hunt the caddisflies outside the building?*	
	(photo or drawing)	(description)

The Polarization worksheet has been adapted from Kriska and Karkus, http://bszm.elte.hu/Kriska_Karkus_konyv.pdf (pp 314-32, in Hungarian)

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Table of points:

Activity	Individual point	Team point	Individual extra	Team extra
Collecting pros and cons about glass surfaces	1 for each	Using science language: 1	Using facts: 1	Using scientific evidence: 1 Referring to scientific phenomenon or law: 1
Experimenting with polarization	1 for description of experiences	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
Preparing polarized filters	1 for usable filter	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
Outdoor observation at day	Safe and respectful work: 1 Data identified: 1 for each row in the table Data organised: 1 for each row in the table Photo or drawing: 2 for each Data analysed: 2 for each appropriate cell Explanation: 2 for each appropriate cell Clear and organised observation sheet:1	If all are ready on time: 2 If >75% ready on time: 1 Otherwise: 0	Outdoor observation at dusk. Safe and respectful work: 1 Data identified: 1 for each row in the table Data organised: 1 for each row in the table Photo or drawing: 2 for each Data analysed: 2 for each appropriate cell Explanation: 2 for each appropriate cell Clear and organised observation sheet:1	If the sum of individual points exceeds 80% of the total achievable: 10

Graphic representation of worksheets	Clearly organised data: 3 Clear representation of findings: 1 Legibility: 1 Proper data processing: 2 Explanation: 2 Presentation: 2 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 they are ready on time and keep the time: 2 x the sum of individual points If they are >75% ready on time and keep the time: 1 x the sum of individual points If they are ready on time and >75% keep the time: 1 x the sum of individual points Otherwise: 0	For speaking up for the team: 5 For making the graphic: 5	If the sum of individual points exceeds 80% of the total achievable: 10
Argumentation	Taking initiative: 1 Clear language:1 Using scientific evidence: 2 Referring to context: 2 Causality: 2 Respectful communication: 1 Referring to information from others: 1 Overall: 10	Sum of individual points of team members	Original ideas: 5	If the sum of individual extra points exceeds 75 % of the total achievable: 2x individual extras Otherwise sum of individual extras.

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Fishbowl	Taking initiative: 1 Clear language:1 Using scientific evidence: 2 Referring to context: 2 Causality: 2 Respectful communication: 1 Referring to information from others: 1 Overall: 10	Sum of individual points of team members	preparing poster or infographics: max. 20	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). Sum of individual extras.

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Template for role-play character card

ATTRACTION TO SHINE CHARACTER CARD	Name:
	Age:
	Sex:
	Occupation:
	Bio/Details/Point of view:

ATTRACTION TO SHINE CHARACTER CARD	Name:
	Age:
	Sex:
	Occupation:
	Bio/Details/Point of view: