



freeland

Promoting STEAM through participatory urban regeneration

2024-1-IT02-KA220-SCH-000251173

Laboratory

Shed light on light pollution

Ref. Luciano Massetti luciano.massetti@cnr.it



Co-funded by
the European Union

FREELAND laboratories follow the structure of Inquiry Based Learning, in 5 steps (orientation, conceptualization, investigation, conclusion and discussion), and for each step we suggest activities and methodological approaches that are engaging for the students such as brainstorming, hands-on, creative works. The activities described in the laboratory are suggestions that teachers can adapt or replace with similar activities suitable to students’ age and school type.

The a	Shed light on light pollution
Duration:	4:5 hours: 1.5 - 2-5 hours outdoors & 2.5 hours indoors
Tools:	Worksheet to print, Pen and notes, questionnaire
Technologies:	Mobile phones for photos, audios and videos, app or device for measuring light intensity, laptop and software for creating presentations and videos, google form for creating a questionnaire
Subjects:	Science (Physics), Mathematics, Civic education, ICT, Art, Social science
Students’ age	Any
School type	Any
Disciplinary contents:	<p>This laboratory focuses on light pollution generated from artificial illumination of urban areas at night. Light pollution is “any alteration of the natural amount of light present at night in the external environment and due to the introduction of light for which man is responsible” (Pierantonio Cinzano) and “the total of all the negative effects of artificial light” (The International Commission on Illumination).</p> <p>The laboratory includes a series of educational and practical activities aimed at raising students’ awareness about the link between artificial light at night and light pollution and at measuring how the selected space is illuminated and proposing solutions to improve the quality of a selected area</p>

Learning objectives:	<p>Students will be able to</p> <ul style="list-style-type: none"> ● to quantify the level of light in the place we live using apps and digital devices. ● present the results of their activities through video and/or presentation ● discuss scientific results and make relationships between diverse disciplines, in connection to light pollution ● reflect on the personal perception of the night environment and the level of illumination
-----------------------------	--

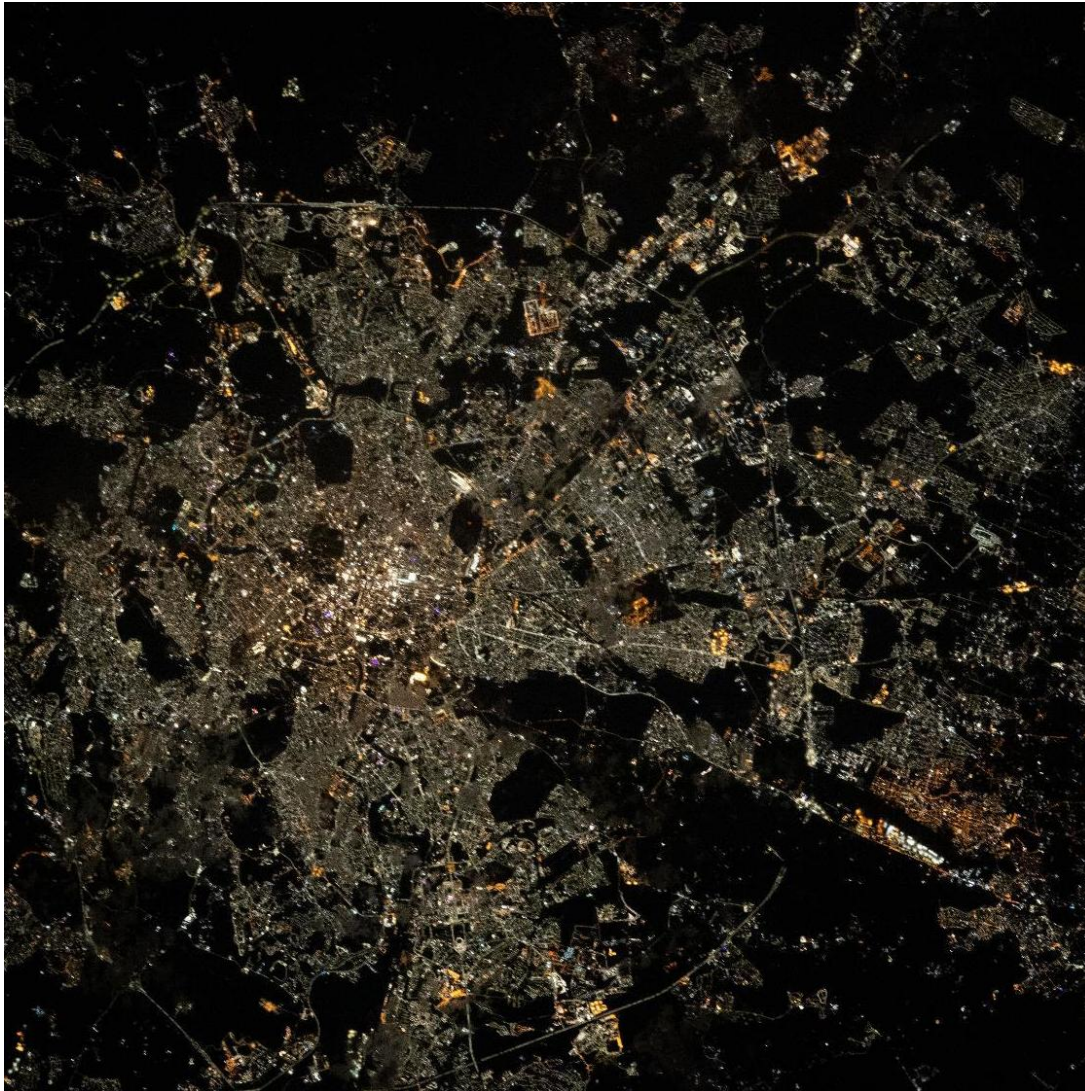
For each phase of the IBL we provide a description of the suggested activities.

Orientation

Duration:	30 minutes indoors
Tools:	No specific tools
Technologies:	PC and projector, app for measuring light intensity
Subjects:	Physics, Civic education, social science, ICT
Method:	Brainstorming

Show an image of a nightscape or a video on an urban environment at night and discuss in the classroom asking students which perception they have, positive and negative feelings about the image or video, what they like and what they don't, if they would be comfortable or not comfortable to be in that place and why. Reflect also on photos taken from space (e.g. example of ISS photo taken from 400km distance <https://eol.jsc.nasa.gov/ExplorePhotos/>). Why can we see the light of the city from space? Is that light useful or not?





*Night image of Rome from the ISS (International Space Station)
(<https://eol.jsc.nasa.gov/ExplorePhotos/>)*

Then, using a light meter app (e.g. lightmeter) or light meter device (e.g. luxmeter or sky quality meter), measure light intensity in the classroom with the curtain down with the lights switch on and switch off. Discuss with the students the difference and their feelings in these two conditions.

Conceptualization

This phase concerns the creation of the question/s to be answered by an investigation.

Duration:	30 minutes outdoors
Tools:	Pen and papers
Technologies:	No
Subjects:	Physics, Civic education, social science
Method:	Brainstorming

Following orientation, the teacher introduces the concept of light pollution.

“Humans use artificial light at night to illuminate the environment and do their activities safely. Light systems that are not properly designed (e.g. producing more light than needed, or illuminating places that don’t be illuminated) cause an excessive presence of light that causes light pollution”

There are two definitions of Light Pollution: “any alteration of the natural amount of light present at night in the external environment and due to the introduction of light for which man is responsible” (Pierantonio Cinzano) and “the total of all the negative effects of artificial light” (The International Commission on Illumination).

Light pollution can be direct (the light of the lamp on the street) or indirect. This type of light pollution is the light that is diffused in the atmosphere (sky glow). Its intensity is lower than direct light pollution, but it can propagate for longer distances.

“Can you say how many artificial lights (e.g. streetlights) are located around your house and which of them you believe appropriate, excessive or disturbing and why?”

Which are the conditions that you need to feel comfortable in an urban or rural environment?”

Investigation

The investigation includes hands-on activities to answer the question posed in the Conceptualization:

“Can you say how many artificial lights are located around your house and which of them you believe appropriate, excessive or disturbing and why?”

Which are the conditions that you need to feel comfortable in an urban or rural environment?”

through the Assessment of the artificial lights (e.g. lamps, luminous signs) and a questionnaire on urban environment perception at night by young people.

Duration:	1 - 2: hours outdoors
Tools:	For each group <ul style="list-style-type: none"> • pens • worksheet “Light inventory” (see annex)
Technologies:	Mobile phone to take pictures, videos and record sounds, app for measuring light intensity, GPS or app with geolocation
Subjects:	Physics, Civic education, ICT, social science
Method:	Hands-on laboratories

Planning and performing the activity

1. Assessment of the artificial lights (e.g. lamps, luminous signs).

Classifying streetlights can be quite complex, as many different features must be considered – from structural aspects to performance indicators that affect both efficiency and environmental impact. Key elements include the lamp’s power, light color, type of technology used, and whether the fixture is shielded upwards to prevent light from projecting into the sky and contributing to light pollution.

Students will observe and classify streetlights based on three specific characteristics.

- If the light source uses LED technology or non-LED technology. This is not easy to determine only by visual check and students can try to ask municipality for this information. By the way in the figure there are two examples of LED and non LED technology



- assess the color temperature, distinguishing between warm light (yellow tones) and cool light (white tones). This characteristic can only be accurately evaluated at night or from nighttime photographs.

LIGHT COLOR



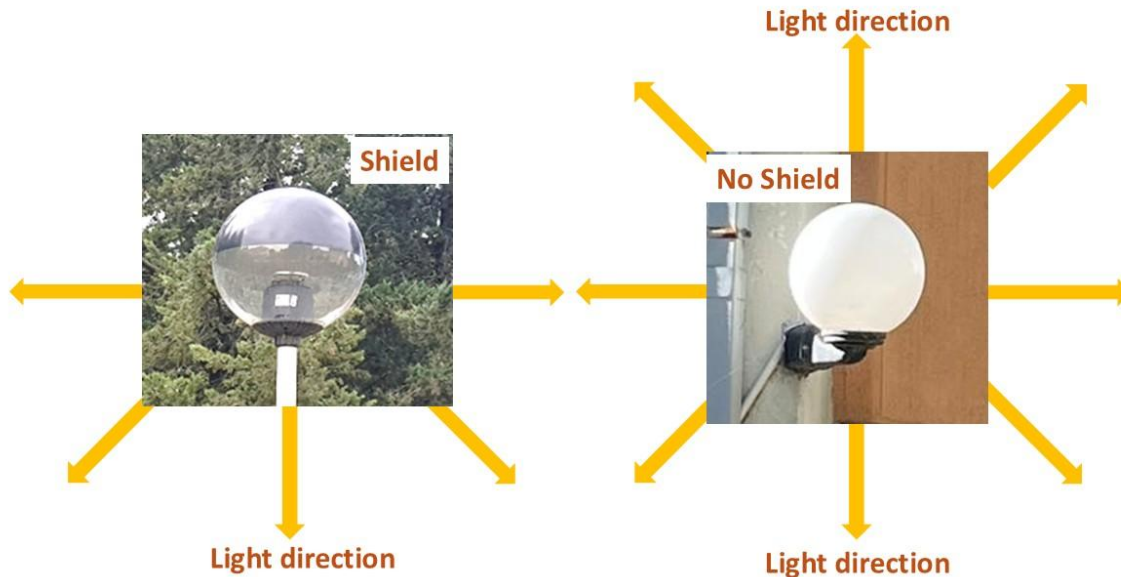
Warm Light (yellow)



Cold Light (white)

- check whether the lamp is upward-shielded, meaning whether the upper part of the fixture is covered to avoid light escaping toward the sky.

SHIELDING OF UPWARD LIGHT OVER THE HORIZON



2. Monitoring light intensity in the place (optional).

Choose one or more spots within the area, and fill in the worksheet “Light intensity on the ground” following the instructions provided in the annex. Take also a picture of the surface and its surroundings.

Note for the teachers:

- 1) students can choose spots that are used by persons (e.g. a bench or a playground).
- 2) The same light intensity can be measured with both methods and recorded by more than one student. These data can be used to do statistics on the variability of evaluation due to student perception (1 method) and variability linked to the sensitivity of the app for different smartphones (2 method).
- 3) **the following activity should be done after sunset.**

Print the worksheets (Appendix) (one per group) to carry out the different laboratories and activities

3 Perception of the night environment (optional).

Students can design and deliver a questionnaire aimed at investigating the perception of the outdoor environment at night by teenagers and/or citizens. In this activity students can design a questionnaire using google form aimed at assessing the young people's perception of urban or rural night spaces. Then, they can organize a night event where participants will fill the questionnaire.

Note for the teacher: limit the number of questions and use closed questions as much as possible. Some examples of questions are: Have you ever heard the term light pollution? Have you ever seen the Milky Way? Does nighttime lighting in cities make you feel safer? Do you believe that the nighttime lighting is excessive where you live?

Conclusion

This phase concerns the analysis of the qualitative and quantitative data gathered in the investigation.

Duration:	1.5 hours indoors
Tools:	Pencils and notes
Technologies:	PC or notebook
Subjects:	Physics, Civic education, Art, Mathematics, ICT
Method:	Report and analysis of the measurements Report and analysis of the questionnaire Draws of student's ideas of improvements/design projects

In Science and mathematics students gather all the results obtained from the investigations. They can arrange collected data for graph analysis in the platform using the collected data.

1. *Assessment of the artificial lights (e.g. lamps, luminous signs).*

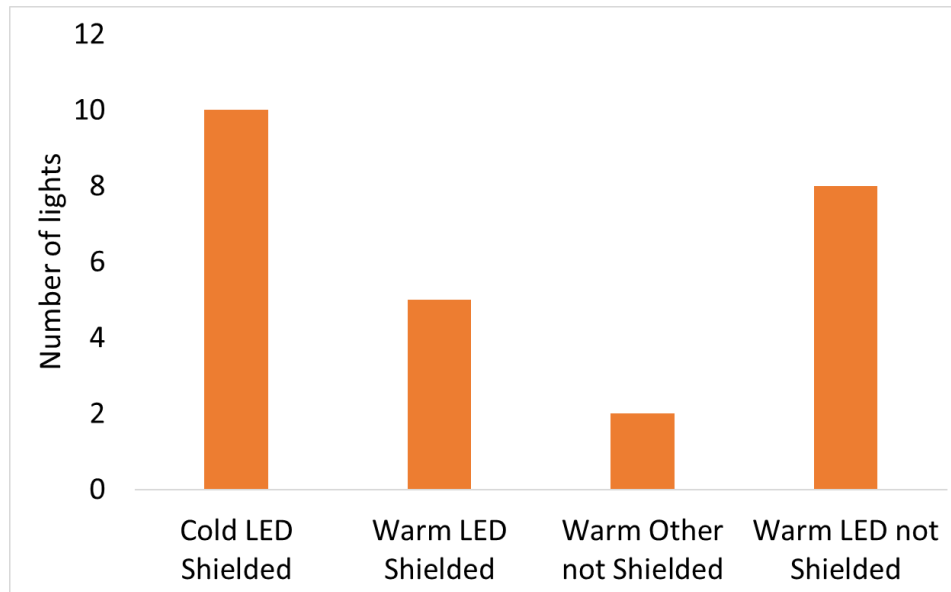
For the analysis, data on paper should be stored in a table (as in the figure) of a spreadsheet or csv file format. The three columns regarding lamp light, color and shield should be combined in a single column to represent all different cases.

Lamp color (Warm/Cold)	Lamp type (LED/Other)	Shield (Yes/No)	Property (public/ private)	Number of lights
<i>Cold</i>	<i>LED</i>	<i>Yes</i>	public	<i>10</i>
Warm	LED	Yes	public	5
Warm	Other	No	private	2
Warm	LED	No	public	5

So starting from the previous table a new table will be produced, combining the three characteristics (type, color and shield) in classes :

Lamp class	Property (public/private)	Number of lights
<i>Cold LED Shielded</i>	public	<i>10</i>
<i>Warm LED Shielded</i>	public	5
Warm Other not Shielded	private	2
Warm LED not Shielded	public	8

For this laboratory we suggest presenting data using a histogram to present the number of lamps in each class. With this data you create the table in spreadsheet or csv format to be uploaded to the platform.



Histogram of number of lamps per type and color

2 Monitoring light intensity in the place (optional).

For this activity students can map measurement taken at night with a light meter on map (e.g. using google map)

Discussion

In this phase students reflect on the findings. They are able to answer the original question and reflect on it.

Duration:	0.5 hour indoors
Tools:	Pen/notes/Powerpoint
Technologies:	PC
Subjects:	Civic Education, Art, ICT
Method:	Brainstorming, group work

Circle time or brainstorming can be useful to involve the students in the discussion phase which will finally answer the initial question. Based on the results obtained by the analysis of the data, each student will be able to tell which are the spots that are more affected by light pollution and can think / propose ways

to reduce light pollution without compromising the perception of safety of the persons that use the place, to be implemented in the 3D modeling platform.

Students should be able to exactly indicate what they would like to add or change in the area and present their design projects or sketches of ideas, or verbal description for the 3D modeling platform. Students can also create pieces of art or performance to raise citizens' and students' awareness about sustainable night lighting. For instance, they can use light painting pictures made in the urban area.



Light painting pictures taken during the Intercomparison Campaign of light pollution measurement devices held in Tuscany in 2015 (Kyba et al. 2015) by a group of scientists in the framework of the COST Action Loss of the Night Network (LoNNe).



Outcomes:

- 3D visualization of the project (one student group will recreate the place virtually with the support of the [Platform](#)).
- Report or presentation or video, that can be evaluated by teachers following the school's evaluation grid.

Additional reading materials:

- Worldwide light pollution map:
<https://www.lightpollutionmap.info/#zoom=3.04&lat=46.7495&lon=19.8793&state=eyJiYXNlbWFWIjoiTGF5ZXJCaW5nUm9hZCIIm92ZXJsYXkiOiJ3YV8yMDE1Iiwib3ZlcmxheWNvbG9yIjpmYWxzZSwib3ZlcmxheW9wYWNpdHkiOiI2MCIImZlYXR1cmVzb3BhY2I0eSI6Ijg1In0=>
- Dark Sky Association (a lot of materials on light pollution, monitoring, impact on the environment and repository of certified dark sky regions in the World:
<https://darksky.org/>

Appendix:

1. Worksheet: Light Inventory
2. Lamp classification (examples)
3. Worksheet: Light intensity on the ground



Co-funded by
the European Union

Disclaimer: Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

1. Worksheet: Light Inventory

Group name: *Urban explorers*

School name: *Lyceum Copernico*

Country: *Italy*

Date: *20/11/2025*

Location: *Prato*

Description of the place: *small green area with concrete and grass surfaces, some trees and benches near a main street*

Lamp color (Warm/Cold)	Lamp type (LED/Other)	Shield (Yes/No)	Property (public/ private)	Number of lights
<i>Cold</i>	<i>LED</i>	<i>Yes</i>	<i>public</i>	<i>10</i>
Warm	LED	Yes	<i>public</i>	5
Warm	Other	No	private	2

Fill in the table following this procedure:

fill the information in the table:

- **Group student name:** indicate the name of the group that makes the measurements
- **School name:** name of the school
- **Country:** country of the school
- **Date:** of the observation
- **Location:** name of the place
- **Description:** provide a brief description of the area: e.g. urban or rural, square, park, street, low or high frequentation at night...

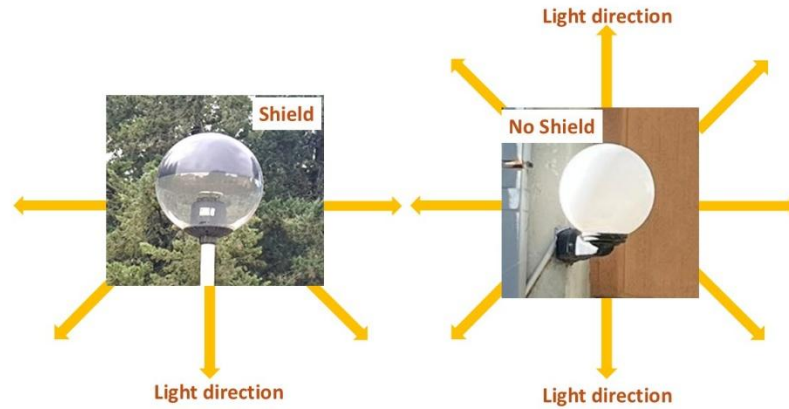
For each type of light fill a row with (for type, color and shielding of lamps refers to the examples in the following figures:



- **Lamp color:** indicate the if the color of the light is yellow (Warm) or white (Cold).
- **Lamp type:** indicate if the type of light is LED or Other type
- **Shield:** indicate if the lamp is shielded (YES)on the upper part to avoid light emission towards the sky or not (NO)
- **Property:** guess if the light is of public or private property
- **Number of lights:** the number of lights present in the area with the same type, color and shielding.

2. Lamp classification

SHIELDING OF UPWARD LIGHT OVER THE GHORIZON



LIGHT COLOR



Warm Light (yellow)



Cold Light (white)

TYPE



Not LED)



LED

3. Worksheet: Light intensity on the ground (Optional)

Group name: *Urban explorers*

School name. *Lyceum Copernico*

Country: *Italy*

Date: *20/11/2025*

Location: *Prato*

Description of the place: *small green area with concrete and grass surfaces, some trees and benches near a main street*

Type of surface	Presence of shade (Yes/No)	Perceived Intensity from 1 (too dark to 5 (too bright))	Light intensity (Lux)	Lat	Long
<i>asphalt</i>	<i>No</i>	<i>3</i>	<i>10</i>	<i>43.111</i>	<i>11.234</i>

Fill in the table following this procedure:

fill the information in the table:

- **Group student name:** indicate the name of the group that makes the measurements
- **School name:** name of the school
- **Country:** country of the school
- **Date:** of the observation
- **Location:** name of the place
- **Description:** provide a brief description of the area: e.g. urban or rural, square, park, street, low or high frequentation at night...

For each type of light fill a row with:

- **Type of surface:** indicate the type of surface (e.g. asphalt, grass, bare soil...)

- **Presence of shade:** indicate if the measured surface is shaded from the light (YES) or not (NO)
- **Perceived intensity:** : look at the selected place and assigns an intensity to the light intensity using a likert scale:: 1 (too dark), 2 (dark), 3 (comfortable), 4 (Bright), 5 (Too bright)
- **Light intensity:** measure and record the intensity of light putting the device (luxmeter or app for smartphone near the ground surface and measure the light coming from above.
- **Lat Lon:** indicate Latitude and longitude of the light using a GPS or smartphone.