STEAMCITY CURRICULUM

# SHINE SMART, SHINE BRIGHT

## Understanding Urban Lighting

thematic: energy and energy efficiency

## Introduction

The **"Shine Smart, Shine Bright" Protocol** aims is an introduction to students regarding the challenges of optimizing daylight usage in city centers and commercial areas. In a context where energy efficiency and citizen well-being are at the heart of urban concerns, this activity offers a practical and reflective approach to understanding and improving urban lighting management.

Through three complementary phases, students will explore current public policies, collect field data, and propose innovative solutions. They will develop skills in critical analysis, scientific methodology, and civic engagement, while addressing key concepts such as light pollution, natural light integration, and energy efficiency.

This activity encourages in-depth reflection on the impact of lighting on our urban environment and invites students to become agents of change in their community. By combining theory and practice, "Shine Smart, Shine Bright" offers a unique opportunity to make concrete contributions to improving our living environment while developing ecological and civic awareness.

### Interdisciplinarity

**biology**

**geography**

### Sustainable Development Goals

7 AFFORDABLE AND CLEAN ENERGY

11 SUSTAINABLE CITIES AND COMMUNITIES

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

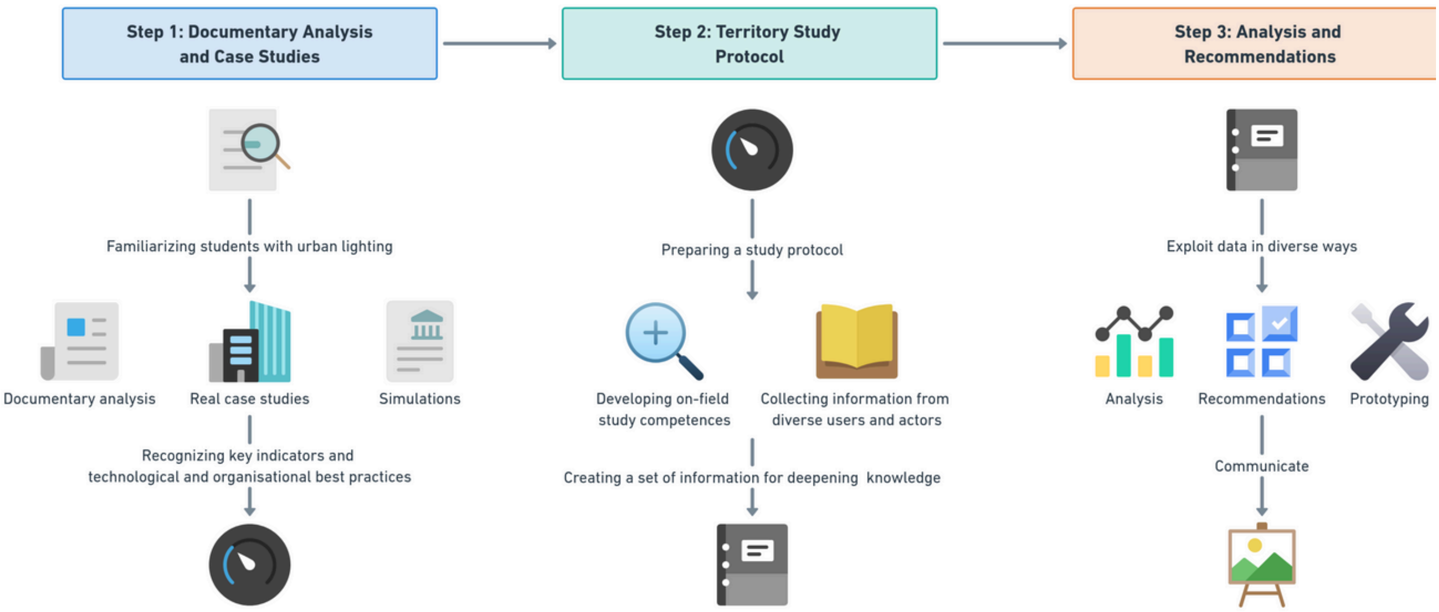
# Overview

## Protocol Structure

**Step 1: Documentary Analysis and Case Studies:** Step 1 lays the foundation of the project by familiarizing students with urban lighting through three main activities. First, they study technical and regulatory documents to understand the current legal framework and standards. Next, they analyze real case studies in groups of cities that have implemented innovative solutions, using a structured analysis grid. Finally, they participate in simulations to apply their knowledge. This first phase allows them to master key concepts such as light pollution, energy efficiency, and adaptive lighting systems. The skills and knowledge acquired prepare them for the subsequent phases of field observation and solution research.

**Step 2: Territory Study Protocol:** Step 2 is a practical study where students analyze the lighting in their area. They observe and document the different types of lighting present, identify well-lit and poorly-lit areas, and evaluate the use of natural light in urban spaces. Students use observation sheets to methodically record their findings in the field. They inventory the types of lighting fixtures present, their condition, positioning, and impact on the urban environment. They also evaluate commercial lighting, particularly store windows and illuminated advertising panels. To complete their observations, students gather feedback from users and merchants through simple questionnaires. These interviews help understand how different stakeholders perceive lighting and identify concrete issues related to urban lighting, such as the sense of security or visual comfort. This approach can be initiated or carried out entirely within the school establishment, allowing students to practice in a familiar environment and avoid constraints related to field study.

**Step 3: Analysis and Recommendations:** The third and final step of the project aims to transform observations and analyses into concrete actions. Students will synthesize their findings from previous phases to develop practical and innovative recommendations regarding urban lighting optimization. This crucial phase enables the transition from theory to practice by proposing solutions adapted to the local context while raising awareness among territorial stakeholders about smart lighting issues. Through the analysis of collected data, development of recommendations, and the possibility of prototyping solutions, students become real agents of change in their community.



## Getting started

The protocol can be fully conducted over two to three sequences. You can decide to perform only step 1 (around 30 minutes to 1 hour), step 1 and 2 (1 classroom sequence + 1 on-site visit), or the full stages (an additional sequence to conclude and propose recommendations).

| Steps | Duration | Difficulty | Material |
|---|---|---|---|
| **Documentary Analysis and Case Studies** | 30 minutes to 1 hour | ★☆☆☆☆ | • Computers or tablets with Internet access for documentary research and/or pre-selected documentation on sleep<br>• Paper, pens for note-taking<br>• Paper/foam board in A3 format (recommended format) for concluding on the step |
| **Territory Study Protocol** | 2 hours (outside the classroom) | ★★★☆☆ | • Cameras or smartphones for documentation<br>• Computers for data analysis |
| **Analysis and Recommendations** | 30 minutes to 1 hour | ★★★★☆ | • Presentation materials (posters, projector)<br>• Prototyping materials depending on chosen projects |

## Glossary

| Keywords & Concepts | Definitions |
|---|---|
| **Light pollution** | Excess artificial night lighting that disrupts the environment and human health. |
| **Energy efficiency** | Optimization of energy consumption to deliver equivalent or superior service. |
| **Natural light** | Sunlight illumination that varies according to time and weather conditions. |
| **Adaptive lighting** | Lighting system that automatically adjusts based on surrounding conditions. |
| **Lux** | Unit of measurement for illuminance, representing the luminous flux received per unit area. |
| **Regulatory framework** | Set of laws and standards governing public and commercial lighting. |
| **Visual comfort** | Lighting conditions that enable clear and comfortable vision, without glare or eye strain. |
| **Nocturnal biodiversity** | Collection of animal and plant species active at night, often affected by artificial lighting. |
| **Smart lighting** | Lighting systems using sensors and automated controls to optimize light usage. |
| **Carbon footprint** | Measure of human activities' environmental impact in terms of greenhouse gas emissions. |
| **Chronobiology** | Study of biological rhythms, particularly the impact of light on circadian cycles. |
| **Photopollution** | Term specifically referring to pollution caused by excessive artificial light. |

# Protocol

## Step 1 - Documentary Analysis and Case Studies

**Background and description of the problem to be solved in this step**: In this first phase, students concretely explore urban lighting policies through document analysis and case studies. Working in small groups, they examine local regulations, municipal reports, and innovative lighting projects. This documentary immersion allows them to discover how different cities manage their lighting, from technical aspects (types of fixtures, control systems) to environmental and economic considerations.

**Learning Objectives**: Students develop practical skills by analyzing technical and regulatory documents on urban lighting. They learn to use a structured analysis grid to evaluate case studies, and practice presenting their findings through posters or digital presentations. Through comparing different lighting management approaches, they acquire the conceptual tools necessary for the next phase of field observation.

### Conceptualisation

Our general hypothesis for the entire protocol is as follows: **better integration of natural light and optimization of artificial lighting in city centers and commercial areas can improve energy efficiency and citizen well-being**.

In this initial phase, we explore how current public lighting policies take into account the use of natural light. This step allows us to lay the groundwork for understanding the current situation and identifying potential gaps in the existing approach. We will analyze current regulations and conduct field observations to evaluate the alignment between policies and practical realities.

This analysis will contribute to our overall understanding of daytime lighting optimization in urban commercial areas, thus allowing us to begin testing our general hypothesis.

To study our hypothesis on urban lighting optimization, we will explore several key concepts that directly relate to our problem:

- **Light pollution** is at the heart of our study. It encompasses **glare**, **sky glow**, and **light trespass**. These phenomena are directly linked to our hypothesis as they represent the negative consequences of poorly optimized lighting. By understanding these aspects, we can better evaluate the impact of current lighting and propose solutions to reduce it.

- **Natural light integration** is a crucial concept for our hypothesis. It involves the use of **adaptive control systems**, **reflective materials**, and specific **architectural designs**. These elements are essential for maximizing natural light use and reducing dependence on artificial lighting, which is central to our optimization hypothesis.

- **Energy efficiency** is another key concept. It encompasses **low-consumption technologies**, **smart management**, **dimming systems**, **presence detectors**, and **advanced LEDs**. These technologies are directly related to our hypothesis as they offer concrete ways to optimize light use while reducing energy consumption.

- Finally, the **regulatory framework**, including **technical standards**, **international recommendations**, and **local policies**, is essential to our study. It will help us understand the legal constraints and opportunities for improvement in urban lighting optimization, a crucial aspect for validating our hypothesis and proposing feasible solutions.

This multidimensional approach, combining the study of light pollution, natural light integration, energy efficiency, and regulatory framework, will allow us to thoroughly evaluate our hypothesis on urban lighting optimization in city centers and commercial areas.

## Students Investigation

**Documentary study and regulatory analysis**

For this first step, the teacher can either prepare a list of relevant documentary resources on **national and local urban lighting regulations**, or let students search for these resources themselves, in class or at home, depending on the modalities, available time, and internet access.

These resources may include **municipal documents, urban planning reports, and scientific articles on urban lighting**. Students, **divided into small groups of 3 or 4 for the entire phase**, will analyze these documents to identify local standards for urban lighting. They will need to focus on lighting schedules, maximum authorized intensities, and energy requirements.

**Case studies**

Still in groups, students will analyze real case studies of innovative urban lighting initiatives and lighting plans.

They will explore solutions such as **centralized lighting management systems**, **light and motion sensors**, and **variable-intensity LEDs, illustrated in real urban areas**.

The teacher will provide a structured analysis grid to guide their thinking, for instance the following, also available for print in appendix.

Date: .../.../......

Group: ............

Subject analyzed: ............

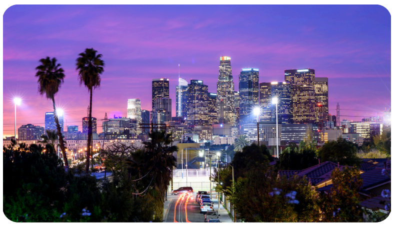
| Analysis Criteria | Description | Evaluation |
|---|---|---|
| Project / Initiative / Public Policy Title | Title and brief description of the initiative | |
| City and Country | Project location | |
| Main Objectives | Intended goals (energy savings, light pollution reduction, safety improvement, etc.) | |
| Initial Problems | Identify the prior situation | |
| Technologies Used | Types of fixtures, control systems, sensors, etc. | |
| Natural Light Integration | Methods to maximize daylight usage | |
| Energy Efficiency | Energy consumption reduction (in percentage if available) | |
| Light Pollution Impact | Measures taken to reduce night sky luminescence and light trespass | |
| Adaptability | System's ability to adjust to changing conditions (weather, seasons, events) | |
| Citizen Involvement | Resident participation in project design or operation | |
| Regulatory Framework | Compliance with local and international standards | |
| Costs and Funding | Project budget and funding sources | |
| Results and Impact | Observed benefits (economic, environmental, social) | |
| Challenges Encountered | Technical, financial, or social obstacles and solutions provided | |
| Replication Potential | Possibility of applying this model in other urban contexts | |

**Here are some examples of initiatives that can be proposed to students for study:**

### Plan Lumière in Lyon, France

Pioneer in smart urban lighting management. Enhances architectural heritage and reduces energy consumption using LED technologies and adaptive control systems.

### LED Program in Los Angeles, USA



Replaced 140,000+ streetlights with LEDs, reducing energy consumption by 63% and CO2 emissions by 47,600 tons annually. Includes remote control and maintenance.

### Toronto (Canada) Green Standards

Guidelines and sustainable design requirements for new private and City-owned developments. Include reducing energy use and greenhouse gas emissions from new buildings with recommendations on lighting.

Each group will present their analysis to the class, highlighting lessons learned and their potential applicability to their own urban context. They will present their findings in 5-minute presentations to the class, in the form of posters or presentations (using Canva, PowerPoint, Prezi, Animaker, etc.), including virtual demonstrations. The teacher will guide a class discussion to synthesize the collected information, identify technological best practices that could be applied locally, and reflect on the implications of these technologies in terms of energy efficiency, cost, and sustainability.

**To help you, a presentation of some graphical tools that could allow students to create an attractive presentation with reduced effort is available in the going further section of this protocol.**

**City simulation and problem solving**

In this final step, students will participate in an interactive **simulation of a fictional city facing various urban lighting challenges**.

The teacher will present a **detailed scenario including problems such as energy overconsumption, light pollution, and lack of security in certain areas**. Students, divided into teams, will play the role of urban lighting consultants. They will need to:

- **Analyze the problems presented in the scenario.**
- **Propose solutions based on knowledge acquired during the documentary study and case study analysis.**
- **Develop a detailed action plan, including technologies to deploy, necessary regulatory changes, and an estimated budget.**
- **Present their plan to the class, which will play the role of the city council.**

This simulation will allow students to practically apply their acquired knowledge, develop their problem-solving skills, and understand the complexities of implementing smart urban lighting solutions in a real-world context.

## Conclusion & Further Reflexion

At the end of this initial documentary research phase, students will have acquired a **deep understanding of urban lighting policies and regulations**. They will have developed skills in **critical analysis of official documents**, **concrete case studies**, and **understanding of technical and regulatory challenges**.

Students will be able to **identify best practices**, **understand technological innovations**, and **connect public policy objectives with concrete solutions**. They will also have gained skills in **comparative analysis of urban initiatives** and **assessment of environmental and economic impacts of different lighting solutions**.

**To deepen reflection on this documentary phase, teachers can use the following questions:**

- "What differences did you observe between the approaches of the different cities studied?"
- "How can technological innovations be adapted to the local context?"
- "What are the main challenges in implementing smart lighting policies?"

# Step 2 - Territory Study Protocol

**Background and description of the problem to be solved in this step**: This phase implements a concrete scientific approach to collect data in city centers and commercial areas within the students' territory. Students will measure light intensity, estimate energy consumption, and gather qualitative feedback on users' perception of lighting. They will also analyze natural light contribution to better understand its potential in reducing energy costs and improving visual comfort.

**Learning Objectives:** This phase aims to develop students' analytical capabilities through the collection and interpretation of both quantitative and qualitative data. Students will learn to evaluate imbalances between artificial lighting and natural light, while establishing concrete connections between their observations and issues of energy, comfort, and quality of life. This approach will also allow students to better understand their territory's specificities and anchor their learning in a tangible local context.

## Conceptualisation

Building on the conclusions from the initial documentary research phase, which identified the main regulatory and technological issues in urban lighting, this second phase seeks to deepen our understanding of the problem by adopting a researcher's perspective. This approach allows students to grasp the fundamental concepts of scientific methodology: hypothesis formulation, protocol development, data collection and analysis.

The hypothesis we wish to explore is simple: **artificial lighting in our city centers is not always adapted to users' real needs, resulting in energy waste and discomfort**

To verify this hypothesis, students will develop a comprehensive investigation methodology, introducing them to key research concepts: dependent and independent variables, parameter control, and measurement reproducibility. This approach begins with collecting objective data, from observations and questionning end-users.

An essential added-value of this protocol will be to favour a qualitative dimension of exploring a research question, through studying and interviewing different territorial stakeholders including end-users, hence introducing students to social science research methods.

Concepts of sample representativeness, observation bias, and qualitative analysis will be addressed during questionnaire design.

**Sample representativeness** refers to the degree to which a sample accurately reflects the characteristics of the larger population from which it is drawn. A representative sample ensures that the findings from the study can be generalized to the broader population.

**Observation bias** is a systematic error that occurs when a researcher's expectations or preferences influence the observations or data collection process. This bias can lead to inaccurate results and conclusions, as the researcher may inadvertently focus on data that supports their hypotheses while overlooking contrary evidence.

**Qualitative analysis** is a research method used to interpret non-numerical data, such as texts, interviews, and observations. It focuses on understanding underlying meanings, patterns, and insights rather than measuring quantities. Qualitative analysis is often used to explore complex phenomena and provide depth to the understanding of participants' experiences and perspectives.

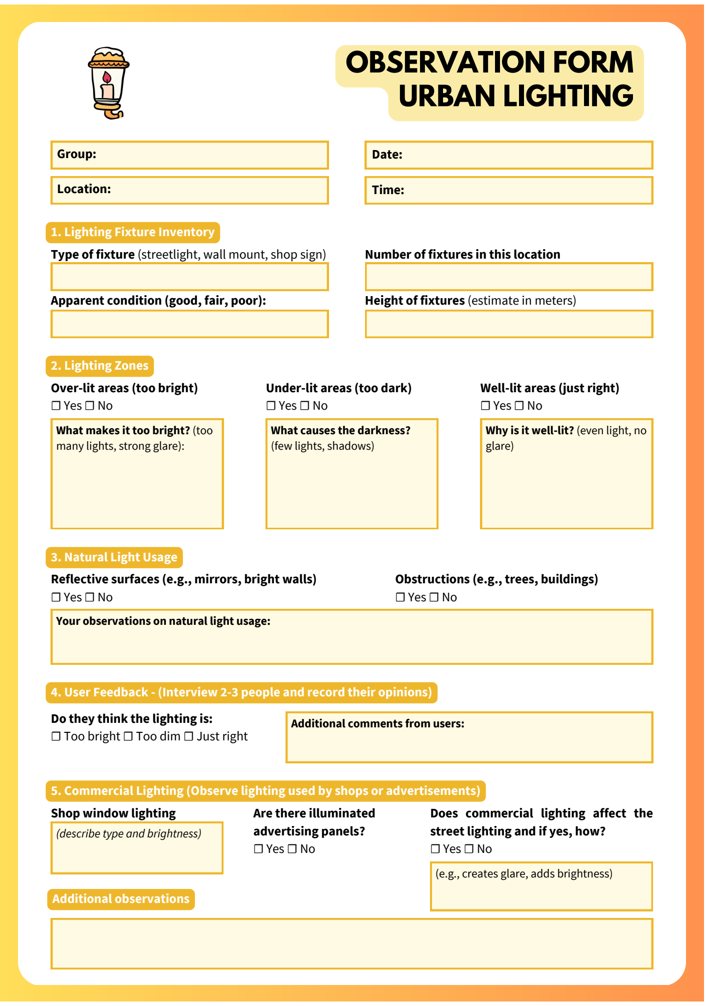
Merchants will be interviewed about their lighting practices, constraints, and specific needs. Passersby and public space users will participate in satisfaction surveys regarding their perception of visual comfort and sense of security. This approach allows capturing the human and social dimension of urban lighting, going beyond mere technical analysis while developing students' critical thinking.

## Students Investigation

Following the documentary and regulatory study phase, case analyses, and simulations, students will have acquired a knowledge base enabling them to **develop a simple study methodology to apply in the field in order to position themselves as observers and analysts of the studied issue**.

Students will design a **lighting study protocol combining visual observations and qualitative feedback**. This protocol may include observing the presence of smart lighting systems (motion detectors, timers), LEDs, and brightness control systems, perceived brightness and general ambiance at different times of day and in various weather conditions, public lighting methods and those used by merchants.

Students will develop **observation forms to record their findings on lighting and technologies used, and evaluate light sources** and **questionnaires** to gather user feedback. These tools are available hereunder as examples and in annex for printing.



OBSERVATION FORM URBAN LIGHTING

Group:

Date:

Location:

Time:

1. Lighting Fixture Inventory

**Type of fixture** (streetlight, wall mount, shop sign)

**Number of fixtures in this location**

**Apparent condition (good, fair, poor):**

**Height of fixtures** (estimate in meters)

2. Lighting Zones

**Over-lit areas (too bright)**
☐ Yes ☐ No

**What makes it too bright?** (too many lights, strong glare):

**Under-lit areas (too dark)**
☐ Yes ☐ No

**What causes the darkness?** (few lights, shadows)

**Well-lit areas (just right)**
☐ Yes ☐ No

**Why is it well-lit?** (even light, no glare)

3. Natural Light Usage

**Reflective surfaces (e.g., mirrors, bright walls)**
☐ Yes ☐ No

**Obstructions (e.g., trees, buildings)**
☐ Yes ☐ No

**Your observations on natural light usage:**

4. User Feedback - (Interview 2-3 people and record their opinions)

**Do they think the lighting is:**
☐ Too bright ☐ Too dim ☐ Just right

**Additional comments from users:**

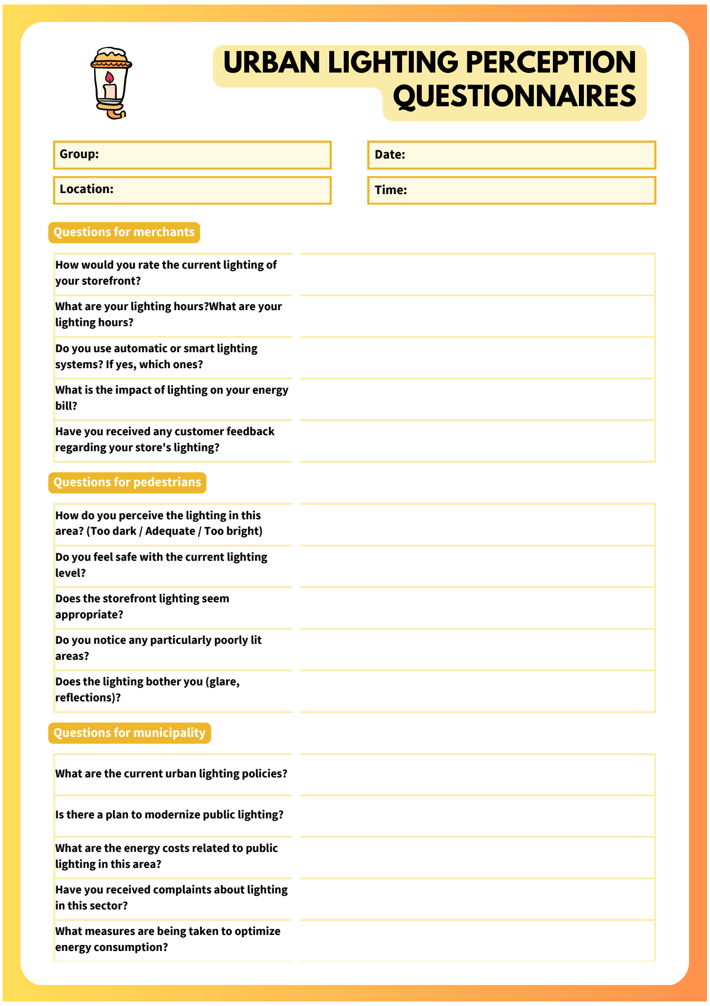
5. Commercial Lighting (Observe lighting used by shops or advertisements)

**Shop window lighting**
*(describe type and brightness)*

**Are there illuminated advertising panels?**
☐ Yes ☐ No

**Does commercial lighting affect the street lighting and if yes, how?**
☐ Yes ☐ No
(e.g., creates glare, adds brightness)

Additional observations



URBAN LIGHTING PERCEPTION QUESTIONNAIRES

Group:

Date:

Location:

Time:

Questions for merchants

| | |
|---|---|
| How would you rate the current lighting of your storefront? | |
| What are your lighting hours?What are your lighting hours? | |
| Do you use automatic or smart lighting systems? If yes, which ones? | |
| What is the impact of lighting on your energy bill? | |
| Have you received any customer feedback regarding your store's lighting? | |

Questions for pedestrians

| | |
|---|---|
| How do you perceive the lighting in this area? (Too dark / Adequate / Too bright) | |
| Do you feel safe with the current lighting level? | |
| Does the storefront lighting seem appropriate? | |
| Do you notice any particularly poorly lit areas? | |
| Does the lighting bother you (glare, reflections)? | |

Questions for municipality

| | |
|---|---|
| What are the current urban lighting policies? | |
| Is there a plan to modernize public lighting? | |
| What are the energy costs related to public lighting in this area? | |
| Have you received complaints about lighting in this sector? | |
| What measures are being taken to optimize energy consumption? | |

Once the method and tools are defined, the teacher will **organize a field trip to a shopping street or central district of the city** to illustrate the issues discovered during the documentary analysis phase and collect various quantifiable and qualifiable elements related to the problem. You can combine the observation sheet with a **mapping tool to create a visualization of the studied points on a map (such as [uMap])**. Students can note the locations of light points, lighting zones, lampposts, reflective or advertising panels... on paper and take a photo of each item of interest. They will identify areas that appear over-lit, under-lit, or unsuitable for their uses, based on their visual observations and brief feedback from users they will interview.

**Advice for Teachers: Protocol Adaptation for an In-School Study.** If you wish to conduct a test phase of the protocol, or if you cannot go into the field in the city, you can carry out this phase while staying within your school. Firstly, this allows students to test and refine their methodology in a controlled and familiar environment before potential application in an urban context. Secondly, this adaptation offers a viable alternative for teachers who, for logistical, administrative, or safety reasons, cannot organize field trips. Although this version is a "scaled-down" form of the initial protocol, it nevertheless allows achievement of essential learning objectives:

- Development of methodological skills in data collection and analysis
- Understanding of lighting and energy efficiency issues
- Learning scientific methodology and critical thinking
- Ability to formulate recommendations based on concrete observations

Moreover, the school building presents a diversity of spaces and uses that makes it an excellent study field, allowing students to confront different lighting issues in a real and meaningful context for them. Here are some tips for implementing the protocol within the school:

**Tip 1: Plan according to school constraints**. Identify available time slots, accessible areas, and necessary authorizations. Consider class schedules, room occupancy periods, and safety rules specific to your school.

**Tip 2: Create a strategic mapping**. Create a detailed plan including different types of spaces (classrooms, corridors, common areas) as well as technical features such as building orientation, natural light sources, and existing electrical installations. This mapping should take into account areas with specific uses (laboratories, computer rooms) that have particular lighting needs.

**Tip 3: Adapt your protocol to school specificities**. Focus on three key aspects: Impact on educational activities (reading, screen work, boards); Lighting variations according to seasons and class schedules; Budgetary and technical constraints specific to public institutions

**Tip 4: Organize multi-source data collection**. Combine: Technical measurements (brightness, energy consumption); Observations during different school activities; User feedback from all stakeholders (students, teachers, staff); Analysis of the school's energy bills

**Tip 5: Integrate maintenance issues**. Take into account: Lighting equipment lifespan; Maintenance costs and frequency; Spare parts availability; Technical skills required for maintenance

## Conclusion & Further Reflexion

Students will develop skills in **documentary research**, **comparative analysis of international case studies**, and **results presentation**. They will learn to compare different urban lighting approaches and identify best practices.

**To deepen reflection, teachers can also use the following opening questions to stimulate discussions:**

- "What differences do you observe between the approaches of different cities studied?"
- "How have technological innovations influenced urban lighting strategies?"
- "Which solutions could be adapted to our local context?"

## Step 3 - Analysis and Recommendations

**Background and description of the problem to be solved in this step**: This phase engages students in analyzing their study protocol, formulating concrete recommendations to optimize lighting in city centers and shops. They will imagine local actions, test solutions, create mini-prototypes (optional), and share their results with the community to raise awareness among decision-makers.

**Learning Objectives:** Students will be led to analyze and evaluate the relevance of the study protocol used, propose solutions based on rigorous analysis, and develop civic actions to test these solutions. They will need to create clear and structured presentations, formulate concrete and feasible recommendations, and may design mini-prototypes to illustrate their solutions. Finally, they will learn to effectively communicate their results to mobilize the community.

### Conceptualisation

The conclusion phase allows students to position themselves as **agents of change** by transforming their observations into concrete actions for their territory. Through presenting their results to local decision-makers and participating in public debates, they develop genuine **civic awareness** and understand their role in improving their urban environment.

This approach will notably allow them to address the following processes at their class level:

- **Scientific mediation** constitutes an essential bridge between technical knowledge and the general public. It includes transforming complex data into accessible information, adapting discourse for different audiences (merchants, elected officials, citizens), creating effective communication materials such as infographics and presentations, and organizing awareness events.
- **Civic engagement** represents students' ability to actively participate in their community life. It manifests through their participation in public consultation processes, presenting evidence-based solutions, developing constructive dialogue with local decision-makers, and mobilizing other citizens around identified issues.
- **Territorial innovation** represents the ability to design and implement solutions adapted to the local context. It is characterized by detailed analysis of territory specificities, proposing solutions that respect local constraints, integrating feedback from different stakeholders, and developing pilot projects to test proposed solutions.

### Students Investigation

To conclude the work around urban lighting issues, students can carry out several actions allowing them to validate their scientific approach.

**Data Analysis**

Students will work in groups of 3-4 to analyze all data collected in the field. Using a collaborative spreadsheet (like Google Sheets), they will compile their observations, measurements, and testimonials. A table template will be provided to facilitate information classification according to different criteria: light intensity, lighting schedules, observed uses, user feedback. This comparative analysis will result in a synthetic document presenting identified strengths and areas for improvement. Students will use simple visualization tools (graphs, heat maps) to represent their conclusions clearly and impactfully.

**Recommendation Development**

Based on case studies from phase 1 and their analysis of elements studied in phase 2, the class will be divided into "thematic roundtables" to work on developing public policy recommendations. Each table will focus on a specific aspect: technical solutions, organizational aspects, possible innovations. Groups will rotate every 20 minutes to enrich each table's reflections and allow each student to think about each key concept. The teacher will provide an evaluation grid allowing students to estimate the feasibility of each proposal according to several criteria: estimated cost, technical complexity, social acceptability, environmental impact. Students use collaborative brainstorming tools (like Miro or whiteboards) to organize their ideas.

**Prototyping Phase (optional)**

If you have the capability and necessary time to implement this step, students can choose simple solutions to prototype in groups of 3/4. Depending on available resources, prototypes could include creating physical models with simple materials (cardboard, LEDs, basic sensors), 3D modeling using SketchUp or TinkerCAD, creating before/after photo montages, lighting simulation with free software like DIALux... Each group will have time (for example one week) to create their prototype, then present it to the class.

## Conclusion & Further Reflexion

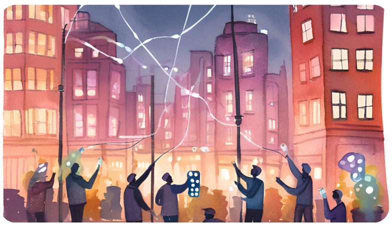
Through this investigation phase, students will have developed skills in **data analysis**, **recommendation development**, and **solution prototyping**. Their comparative data analysis work, combined with formulating concrete proposals and possibly creating prototypes, will allow them to understand the practical challenges of optimizing urban lighting.

**To conclude the entire protocol and open up other perspectives, teachers can use the following questions:**

- "How could your study protocol be improved for future use?"
- "What were the main challenges encountered during data collection and analysis?"
- "How has this study changed your perception of urban lighting and its impact on the city?"

# Exploring the issue through expended projects

## Create a network of light sensors to map urban lighting



Inspired by the **Open Light Sensor Network** project (https://www.opensensornetwork.org), this activity allows students to create their own urban lighting monitoring network. Students will begin by assembling sensors using Arduino Uno or Raspberry Pi boards equipped with LDR photoresistors and ESP8266 WiFi modules. To protect this equipment, they will design and 3D print enclosures. Programming will be done in Python or Arduino IDE, with implementation of a MySQL database to store measurements and a web interface developed with Flask or Node.js. Collected data can be visualized on an online platform and shared with local decision-makers to optimize public lighting.

## Conduct a participatory energy audit of businesses

This approach is based on the **Eco-Responsible Business program** (https://www.eco-commerces.fr) and the European "Smart Retail" project, which demonstrated potential energy savings of 30% in participating businesses. Students will develop a standardized audit questionnaire and use professional tools such as wattmeters, light meters, and infrared cameras for thermographic analysis. In close collaboration with the local Chamber of Commerce and Industry, they will benefit from training provided by energy efficiency experts. Their study results will be presented during participatory workshops, thus creating lasting connections between the school and local economic fabric while developing concrete skills in energy analysis.

## Design an interactive exhibition on light pollution

This artistic and scientific installation is inspired by the **Loss of the Night** project (https://lossofthenight.blogspot.com) and the remarkable "Dark Skies" exhibition at London's Natural History Museum. The heart of the exhibition will be an interactive model of a neighborhood equipped with a variable lighting system using programmable WS2812B LEDs. Students will also develop dynamic mapping of light pollution measurements and create a virtual night sky observation station. The interactive aspect will be enhanced by touch interfaces developed with Processing and a mobile visit application. A special space will be dedicated to demonstrating impacts on wildlife, using presence sensors to trigger educational animations. This exhibition can be presented at local events or installed in public spaces to maximize its educational reach.

# Explore design and creative digital tools

## Canva


**Creation of graphics, videos, infographics... with real-time collaboration**

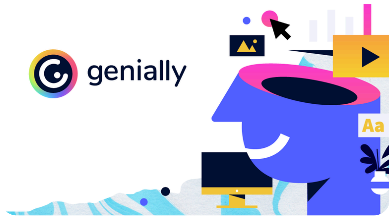
Resources provided: Images, graphics, videos, audio elements

Accessibility: Very accessible

Free features: Access to thousands of templates, basic graphic elements, limited cloud storage

Education Plan available freely for teachers

## Genially



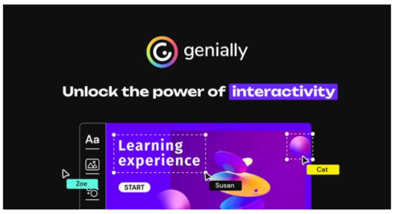

**Creation of interactive presentations, infographics, games, animated content**

Resources provided: Images, graphics, animations

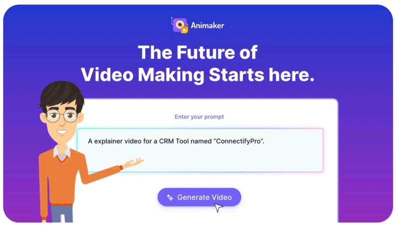
Accessibility: Accessible

Free features: Access to basic templates, limited interactive features, public publications

Reduce fee for professional account access for educators




## Animaker



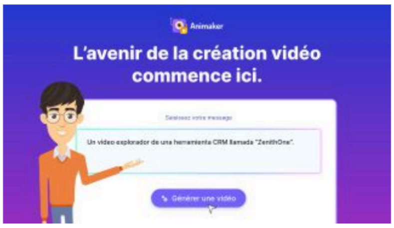

**Creation of animated videos, video infographics, video presentations, animated GIFs**

Resources provided: Images, graphics, audio elements, animations

Accessibility: Moderately accessible

Free features: SD video export, limited access to resources, watermark on videos

No plan for education



## Powtoon

**Creation of graphics, presentations, videos, infographics, real-time collaboration**

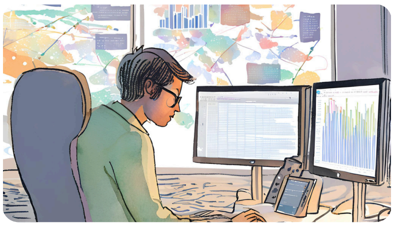
Resources provided: Images, graphics, audio elements, animations

Accessibility: Accessible

Free features: SD video export, limited access to resources, watermark on videos

Reduce fee for professional account access for educators


## Piktochart



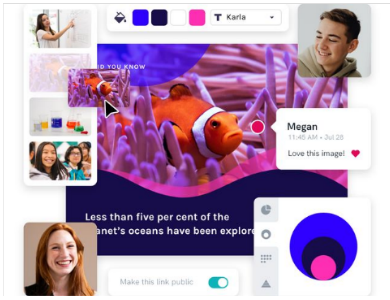
**Creation of infographics, presentations, reports, posters**

Resources provided: Images, graphics, icons

Accessibility: Very accessible

Free features: Access to basic templates, limited export to certain formats, limited storage

Reduce fee for professional account access for educators




## Freepik & Flaticon


**Access to free and premium design resources, icons, and illustrations**

Resources provided: Images, icons, illustrations

Accessibility: Very accessible

Free features: Free access to basic resources with attribution

No plan for education

[https://www.freepik.com](https://www.freepik.com)

[https://www.flaticon.com](https://www.flaticon.com)

# Bibliography


- **Books**

**Urban Lighting for People: Evidence-Based Lighting Design for the Built Environment** by Navaz Davoudian
Explores the needs and experiences of people at night and how these can be addressed by public lighting.

**Light for Cities: Lighting Design for Urban Spaces. A Handbook** by Ulrike Brandi and Christoph Geissmar-Brandi
Provides concrete examples illustrating solutions for urban lighting tasks, enhancing the attractiveness of urban downtown areas.

**The Human and Social Dimension of Urban Lightscapes** by Daria Casciani
Explores new criteria for integrating human psychology in the design of modern urban lighting, focusing on nocturnal urban experiences.

- **Articles**

**Optimization of Urban Street Lighting Conditions Focusing on Energy Saving, Safety, and Users' Needs**
Discusses methods for improving urban street lighting through new technologies and smart management systems.

**Sustainable Uniform Urban Lighting: Multi-Objective Optimization and Its Application**
Develops a comprehensive optimization framework for urban lighting, addressing energy consumption and light pollution.

**The Sustainability Coefficient of Urban Open Space Illumination**
Examines how reduced night-time lighting can improve privacy, facilitate night sky observation, and reduce energy costs.

- **Videos**

**The Dark Side of Light: TED Talk by Paul Bogard**
A concise introduction to the problems of light pollution and solutions for urban areas.

**Dark City: Mark Major - TEDxSydney**
Mark Major explains how urban lighting design often benefits from a "less is more" approach, emphasizing simplicity and sustainability.

**Smart Street Lights: Safe + Smart City Helmond**
Demonstrates dynamic smart street lighting systems that enhance safety, reduce energy consumption, and improve the quality of urban life.

**A Sensorial Journey through Lighting: Rhea Mehta - TEDxRAPodarCollege**
Rhea Mehta discusses the power of lighting to influence emotions, behavior, and experiences in urban environments.

**The Possibilities of Human-Centric Lighting: Sarah Klein - TED@Merck KGaA**
Sarah Klein explores how lighting can support human emotional and biological well-being, advocating for a human-centric design approach.

**Smart Lighting, Smarter Cities**
This video highlights how cities can use smart lighting networks to save up to 80% in energy costs while improving urban infrastructure.

- **Projects and Technologies**

[SoftLight Projects – Urban Lighting from Basics to Applications]
A comprehensive resource dealing with the complex aspects of urban lighting, balancing technical and emotional considerations.

[Intelligent Street Lighting]
Overview of adaptive street lighting systems that adjust to movement by pedestrians, cyclists, and cars.

[Distributed Intelligent Illumination Control in the Context of Probabilistic Graphical Models]
Presents a distributed energy-saving illumination control strategy for lighting networks using probabilistic graphical models.

[Recovering the City Street Lighting Fraction from Skyglow Measurements]
Analyzes the impact of street lighting on urban skyglow and methods to measure and mitigate light pollution.

- **Citizen Science**

[Globe at Night]
A citizen science project inviting the public to measure and report light pollution.

[Light Pollution Map]
Provides a global interactive map to visualize light pollution levels.

[Skyglow Project]
A photography initiative raising awareness about the effects of urban lighting.

# Observation Form - Urban Lighting

## OBSERVATION FORM URBAN LIGHTING

**Group:**

**Date:**

**Location:**

**Time:**

### 1. Lighting Fixture Inventory

**Type of fixture** (streetlight, wall mount, shop sign)

**Number of fixtures in this location**

**Apparent condition (good, fair, poor):**

**Height of fixtures** (estimate in meters)

### 2. Lighting Zones

**Over-lit areas (too bright)**
☐ Yes ☐ No

**What makes it too bright?** (too many lights, strong glare):

**Under-lit areas (too dark)**
☐ Yes ☐ No

**What causes the darkness?** (few lights, shadows)

**Well-lit areas (just right)**
☐ Yes ☐ No

**Why is it well-lit?** (even light, no glare)

### 3. Natural Light Usage

**Reflective surfaces (e.g., mirrors, bright walls)**
☐ Yes ☐ No

**Obstructions (e.g., trees, buildings)**
☐ Yes ☐ No

**Your observations on natural light usage:**

### 4. User Feedback - (Interview 2-3 people and record their opinions)

**Do they think the lighting is:**
☐ Too bright ☐ Too dim ☐ Just right

**Additional comments from users:**

### 5. Commercial Lighting (Observe lighting used by shops or advertisements)

**Shop window lighting**

*(describe type and brightness)*

**Are there illuminated advertising panels?**
☐ Yes ☐ No

**Does commercial lighting affect the street lighting and if yes, how?**
☐ Yes ☐ No

(e.g., creates glare, adds brightness)

### Additional observations

# Urban lighting perception questionnaires

## URBAN LIGHTING PERCEPTION QUESTIONNAIRES

| | |
|---|---|
| **Group:** | **Date:** |
| **Location:** | **Time:** |

### Questions for merchants

| | |
|---|---|
| How would you rate the current lighting of your storefront? | |
| What are your lighting hours?What are your lighting hours? | |
| Do you use automatic or smart lighting systems? If yes, which ones? | |
| What is the impact of lighting on your energy bill? | |
| Have you received any customer feedback regarding your store's lighting? | |

### Questions for pedestrians

| | |
|---|---|
| How do you perceive the lighting in this area? (Too dark / Adequate / Too bright) | |
| Do you feel safe with the current lighting level? | |
| Does the storefront lighting seem appropriate? | |
| Do you notice any particularly poorly lit areas? | |
| Does the lighting bother you (glare, reflections)? | |

### Questions for municipality

| | |
|---|---|
| What are the current urban lighting policies? | |
| Is there a plan to modernize public lighting? | |
| What are the energy costs related to public lighting in this area? | |
| Have you received complaints about lighting in this sector? | |
| What measures are being taken to optimize energy consumption? | |