



# SPACE WEEK

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## Resource Book for Teachers TOPIC: INVESTIGATING LIGHT POLLUTION

Theme		Light Pollution	
Curriculum		<p><b>Strands:</b> Energy &amp; Forces. <b>Strand Unit:</b> Investigate reflection</p> <p><b>Strand:</b> Science and the environment. <b>Strand Unit:</b> Environmental awareness: identify positive aspects of natural and built environments through observation, discussion and recording.</p> <p><b>Strand Unit:</b> Science and the environment: Identify ways which science and technology contributes positively to society/human activities which have positive or adverse effects on local and wider environments.</p> <p><b>Strand:</b> Materials. <b>Strand Unit:</b> Describe and compare materials/investigate how materials can be used in construction/identify how materials can be used.</p> <p><b>Class Level:</b> 3<sup>rd</sup>-6<sup>th</sup> Class</p> <p><b>Curriculum Links:</b> Geography: Environmental awareness/Human Environments. Art: Construction</p>	
<b>Engage</b>			<p>Considerations for inclusion</p> <p>Consider any potential area of difficulty for students with special educational needs.</p>
The Trigger	Wondering	Exploring	
<p>"Black Marble" maps of light pollution <a href="https://www.nasa.gov/specia ls/blackmarble/media/BlackMarble_2016_EuroAfrica_composite.png">https://www.nasa.gov/specia ls/blackmarble/media/BlackMarble_2016_EuroAfrica_composite.png</a></p>	<p>Where are the darkest parts of Ireland?</p> <p>What sorts of objects emit light at night time?</p> <p>What can you name a natural source of light?</p> <p>Can you name an artificial source of light?</p> <p>Do all animals sleep at night?</p> <p>Can you have a shadow at nighttime?</p> <p>Why do we use lampshades in our houses?</p> <p>Why are streetlights important?</p>	<p>Use Stellarium (<a href="#">free download here</a>) to explore the night sky.</p> <p>What is the effect of light pollution on visibility? (use Stellarium Guide to explore Light Pollution here)</p> <p>Or</p> <p>Compare images of urban skies to images of pristine night skies.</p> <p>How is light pollution caused?</p> <p>Light Pollution is often described in terms of Glare, Light Trespass and Skyglow – can children find examples of each of these in their neighbourhood?</p>	
<b>Investigate: How can we reduce light pollution effects?</b>			
Starter Question	Predicting	Conducting the Investigation	Sharing: Interpreting the data / results
Can we reduce the amount of light going into the sky from a model streetlight but still see the ground where we need it?	What materials are best for a light shielding device?	<p>Use a variety of materials to design and make light shields.</p> <p>See how well light shields work by counting stars in box planetarium (instructions here)</p> <p>Record results and comparisons in a table (stars without shield/stars with shield).</p>	<p>Compare data of stars visible before/after light shielding.</p> <p>Use this data to decide which designs are most effective.</p> <p>Do the most effective light shields allow light to the ground where it is needed?</p>
<b>Take The Next Step</b>			
Applying Learning		Making Connections	Thoughtful Actions
<p>Participate in Globe at Night: <a href="https://www.globeatnight.org/">https://www.globeatnight.org/</a></p> <p>Participate in Earth Hour: <a href="https://www.earthhour.org/">https://www.earthhour.org/</a></p> <p>What is the effect of light pollution on animal life? <a href="https://www.noao.edu/education/files/TheNightYouHatched.pdf">https://www.noao.edu/education/files/TheNightYouHatched.pdf</a></p>			

	<p>Find out about Dark Skies in Ireland and around the world: <a href="http://www.mayodarkskypark.ie/">http://www.mayodarkskypark.ie/</a>, <a href="http://kerrydarksky.com/">http://kerrydarksky.com/</a> and <a href="http://www.darksky.org/">http://www.darksky.org/</a></p> <p>Find out how assessing the lighting needs of your school is linked with your Green Schools 'Energy' award.</p>	
<p>Reflection</p>	<p>Did I meet my learning objectives?          Are the children moving on with their science skills?          Ask the children if they enjoyed the lesson.          What questions worked very well?          What questions didn't work well?          Ask the children would they change anything or do anything differently.          Are there cross curriculum opportunities here?</p>	

## Investigation: Can we design a device to reduce light pollution from a model street light?

In this activity the teacher will set up a model street scene with street lights in a large cardboard box. A smaller shoe box 'planetarium' will project stars onto the 'sky' inside the box. Students will assess the visibility of stars without a street light, with a street light and then with a shielded street light. Can we improve the design of lights to reduce the effects of light pollution in our local environment?

## Preparation

**Strands:** Energy & Forces. **Strand Unit:** Investigate reflection

**Strand:** Science and the environment. **Strand Unit:** Environmental awareness: identify positive aspects of natural and built environments through observation, discussion and recording.

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**Strand:** Materials. **Strand Unit:** Properties and Characteristics of materials.

**Class Level:** 3<sup>rd</sup>-6<sup>th</sup> Class

**Curriculum Links:** Geography: Environmental awareness/Human Environments. Art: Construction

### Background

Light pollution is excessive, misdirected, or obtrusive artificial (usually outdoor) light.

The natural night sky is our common and universal heritage, yet it's rapidly becoming unknown to the newest generations. More than half of the world's population now live in cities, 3 out of every 4 people in cities have never experienced the wonderment of pristinely dark skies. Light pollution is a concern on many fronts: safety, energy conservation, cost, health and effects on wildlife, as well as our ability to view the stars.

### Environment:

Light pollution disrupts our natural environment, which, for billions of years has evolved to rely on Earth's predictable rhythm of day and night. Nocturnal animals are particularly impacted by artificial light at night. Some animals, such as turtles, rely on the light of the Moon to guide hatchlings to the sea. They can be confused by streetlights near hatching beaches and do not survive.

### Our health:

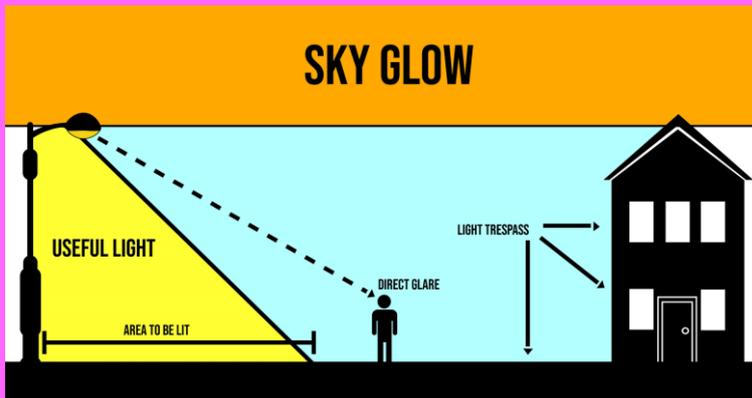
Studies show that exposure to artificial white light sources (screens, white LED, fluorescent lights) suppress our bodies transition into night-time mode. Melatonin helps keep us healthy. If humans are exposed to a lot of white light melatonin production can be suppressed. Research suggests that artificial light at night can negatively affect human health, increasing risks for obesity, depression, sleep disorders, diabetes and certain forms of cancers.

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**Energy :**

Lighting is responsible for at least one-fourth of all electricity consumption worldwide. In Ireland, public lighting is estimated to account for 15-35% of a local authority’s energy use. The 420,000 streetlights in Ireland use a total of 205 GWh (gigawatt hours) of electricity annually at a cost of €29 million and produce 110,000 tonnes of carbon dioxide.

As much as 20-30% of this energy could be wasted through poorly designed or inefficient lighting and the illumination of areas where light is not needed. Over-illumination or misdirected lighting can constitute energy wastage, especially upward directed lighting at night.



**Glare** from unshielded lights can have the effect of inhibiting night vision.

**Light Trespass** occurs when unwanted light enters one’s property, for example, by shining unwanted light into a bedroom window of a person trying to sleep or read or relax!

**Sky glow** refers to the glow effect that can be seen over populated areas. Skyglow is the combination of all the reflected light and upward-directed (unshielded) light escaping up into the sky. Skyglow is very evident around populated areas and can be seen at distances far from the source.

**Solution**

Light travels in straight lines. An unshielded light will let light out in all directions so light escapes up into the night sky.

Technology can allow us to develop ‘smart lights’ which only light areas needed, can be sensor activated and dimmed during different times of the night.

This cuts down on energy use and reduces the effect of artificial light at night on the environment.

Engineers and product designers are constantly working on more efficient ways of designing outdoor lighting to reduce the effects of light pollution on our communities and environment.

**Student Background:** students may have learned about the reflective properties of light, perhaps with these [DPSM Activities](#).

Students may have used Stellarium to explore the night sky and the effect of light pollution.

This short film '[Losing the Dark](#)' introduces the environmental effects of artificial light at night.

### Materials/Equipment

- A large cardboard box to act as street scene with figures (eg. lego people, trees, houses).
- A light box planetarium: a shoe box with tinfoil as the lid. Tiny holes are punched in the tinfoil, the smaller and more numerous the better. A mobile phone torch inside the shoe box works very well as a light source. The light box is placed into larger box to project a model night sky ([design adapted from this activity](#)).
- Street lights: mini mag lights, tops removed to allow light spill out.
- Scissors, tape or glue.
- Various materials: tin foil, card, crepe paper, plastic, parchment paper etc.

**Preparation:** Collection of materials and equipment. Construction of light box planetarium.

## Activity

**Setting the Scene:** Discuss the night sky. Have you ever seen the Milky Way? Can anyone name a constellation? What do we know about nocturnal animals?

Discussion about why the view of the night sky might be different in urban vs. rural areas. Introduce the words skyglow and light trespass.

**Trigger Questions:** Why do we need lights at night time? What is pollution? Would human exploration be different if we never saw the night sky? Can you give examples of glare or light trespass that might affect or come from your home? What bright objects in the sky can reduce the visibility of stars? Why do we need lights in towns and cities? Do all outdoor lights *help* to illuminate? Can you think of ways to reduce the amount of not useful light escaping into the environment?

**Development of Activity:** What properties of light mean that we can direct light escaping upward from streetlights? Imagine you are an engineer, can you design and make a device to direct light downward?

**Safety:** Safety with scissors/safety with light fixtures/heat/electricity.

**Activity:** Set up the light box planetarium in the larger street scene box. Count the numbers of stars visible inside the box. **Record numbers in a table.** Make notes of the quality or brightness of the stars. Students make other observations of the scene – is the model person visible? Is the footpath visible? Would a person feel safe walking here at night?

**Place model street lamp inside.** Observe the visibility of stars. Count and record numbers of stars. Again make observations: is the model person visible? Is the footpath visible? Would a person feel safe walking here at night?

Discuss the light energy being lost to the sky. How can that be stopped or directed downward?

Design and make light shields for the street lights.

Repeat steps with light shields fitted, recording numbers of stars visible.

## Review

How has a light shield improved the visibility of the night sky? Has it also kept the footpath lit for people at night time?

Compare data between individual light shield designs in a table on the blackboard. Which designs worked best?

What are the properties of the best designs, which materials and features did they have?

If the teacher was the Mayor of the town, which design would they choose?

**Assessment:** Students describe their individual design and rationale of features and material choices.

### Follow Up Activities

Students can learn a constellation and try to spot it in the night sky (winter activity).

Students can participate in a [‘citizen science’ activity](#) with the Globe at Night to record and submit scientific data on light pollution.

Reflections and Satellites: DPSM Activity :

[http://www.primaryscience.ie/media/pdfs/col/satellites\\_and\\_reflections\\_activity.pdf](http://www.primaryscience.ie/media/pdfs/col/satellites_and_reflections_activity.pdf)

Investigating Light: Reflection ESERO Activity

[https://esero.ie/wp-content/uploads/2015/01/49\\_Reflecting-light.pdf](https://esero.ie/wp-content/uploads/2015/01/49_Reflecting-light.pdf)

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## Activity: Using Stellarium to explore the effects of light pollution on the night sky

Become familiar with Stellarium to use in the classroom.

Stellarium is a free open source planetarium for your computer. It shows a realistic sky in 3D, just as you would see with the naked eye, binoculars or a telescope. Stellarium is very simple to use and a very effective tool for exploring the night sky.

This guide outlines using Stellarium to explore the night sky in the context of the effect of light pollution. You are however encouraged to use the program for other investigations of the night sky also.

Stellarium can be downloaded from [stellarium.org](http://stellarium.org). Download the latest version of Stellarium available for your operating system.

### Windows

Double click on the latest version of stellarium .exe file to run the installer.

Follow the on-screen instructions.

### MacOS X

Locate the Stellarium .dmg<sup>[6]</sup> file in Finder and double click on it or open it using the Disk Utility application. Now, a new disk appears on your desktop and Stellarium is in it.

Open the new disk and please take a moment to read the ReadMe file. Then drag Stellarium to the Applications folder.

Note: You should copy Stellarium to the Applications folder before running it — some users have reported problems running it directly from the disk image (.dmg)

### Running Stellarium

Windows The Stellarium installer creates an item in the Start Menu under Programs section. Select this to run *Stellarium*.

MacOS X Double click on the *Stellarium* application

When Stellarium first starts, we see a green meadow under a sky. Depending on the time of day, it is either a day or night scene. At the bottom left of the screen, you can see the status bar. This shows the current observer location, field of view (FOV), graphics performance in frames per second (FPS) and the current simulation date and time. The rest of the view is devoted to rendering a realistic scene including a panoramic landscape and the sky. If the simulation time and observer location are such that it is night time, you will see stars, planets and the moon in the sky, all in the correct positions. You can drag with the mouse on the sky to look around or use the cursor keys. You can zoom with the mouse wheel or the Page up or down keys. Much of Stellarium can be controlled very intuitively with the mouse.

The way Stellarium is shown on the screen is primarily governed by two menus. These are accessed by dragging the mouse to the left or bottom edge of the screen, where the menus will slide out. The controls in the main tool bar at the bottom provide a mechanism for turning on and off the visual effects. When the mouse is moved to the bottom left of the screen, a second toolbar becomes visible. All the buttons in this side toolbar open and close dialog boxes which contain controls for further settings of the program.

<i>Feature</i>	<i>Button</i>	<i>Key</i>	<i>Description</i>
Constellations		C	Draw constellations as “stick figures”
Constellation Names		V	Draw name of the constellations
Constellation Art		R	Superimpose artistic representations of the constellations
Constellation Boundaries		B	Draw boundaries of the constellations <sup>1</sup>
Equatorial Grid		E	Draw grid lines for the equatorial coordinate system (RA/Dec)
Quit Stellarium		Ctrl + Q	Close Stellarium.
Help Window		F1	Show the help window, with key bindings and other useful information

Fig 1. Some Control features of bottom tool bar

View Window		F4	Show the view window
Time Window		F5	Show the time window
Location Window		F6	Show the observer location window (map)

Fig 2. Features of side toolbar

The first setting to adjust when opening Stellarium is the date, time and location. This can be done using the



buttons in the side toolbar. If the time is set to daylight hours the sky will appear as is in the day time with sun at appropriate position. Stellarium will then run in real time (time will pass at the same speed as normal time). For the purposes of this exercise time can be moved forward or backward a number of hours to a night-time hour. The sky will then appear dark and stars will be visible.

The position of the stars in the sky is dependent on your location on Earth (or other planet) as well as the time and date. For Stellarium to show accurately what is (or will be/was) in the sky, you must tell it where you are. You only need to do this once – Stellarium can save your location so you won't need to set it again until you move.

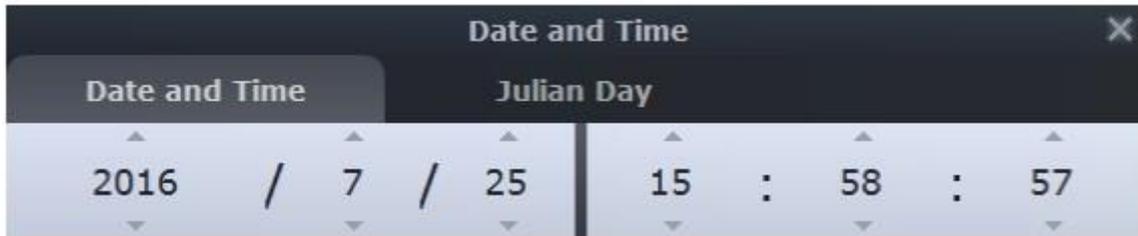


Fig 3. Time dialog box



Image 4. Location dialogue box

Take some time at this point to explore the other view options as shown in fig. 1.0 above.

The constellations visible will be specific to the location and date as you set on opening. Time can be sped up so as to observe the movements of stars across the sky over the course of a night using the buttons on bottom menu bar.

Button	Shortcut key	Description
	J	Decrease the rate at which time passes
	K	Make time pass as normal
	L	Increase the rate at which time passes
	8	Return to the current time & date

Fig. 5 Shortcut keys

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Constellations can be explored by turning on or off the names, outlines or the artistic representations functions.



Fig. 6 Night Scene with constellation artwork and moon

### Moving around the sky

The sky in Stellarium can be intuitively explored with the mouse or keyboard cursors. Objects in the sky can be selected, or zoomed in or out. You can click and drag the sky with left mouse to change the point of view. The table shows basic navigation functions

Key	Description
Cursor keys    	Pan the view left, right, up and down
 /Page Up, Ctrl+  /Ctrl+ 	Zoom in and out
Left mouse button	Select an object in the sky
Right mouse button	Clear selected object
Centre mouse button (wheel press)	Centre selected object and start tracking
Mouse wheel	Zoom in and out
	Centre view on selected object
Forward-slash (  )	Auto-zoom in to selected object
Backslash (  )	Auto-zoom out to original field of view

### Changing the levels of light pollution

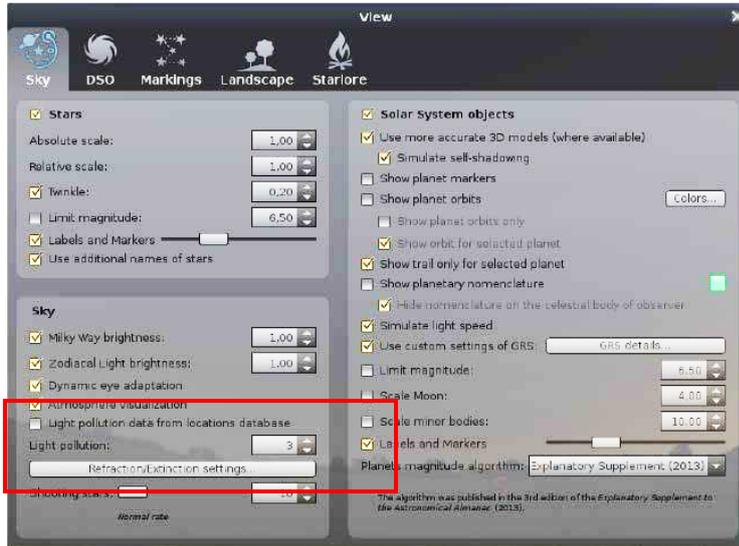
The light pollution levels can be adjusted so we can consider the effects of light pollution on the visibility of the night sky.

This can be done using the View Settings window selected from the side toolbar.

A dialogue box opens with five tabs,



It is the SKY box we are interested in here.



Stellarium simulates light pollution and is calibrated to the Bortle Dark Sky Scale where 1 means a good dark sky, and 9 is a very badly light-polluted sky. The box for 'light pollution data from location database' should remain unchecked to allow the user to increase or decrease levels of light pollution.

The dialogue box can be closed by 'x' on right hand side.

There are of course so many other possibilities of learning using Stellarium and one is encouraged to explore freely or research the User Guide PDF on [stellarium.org](http://stellarium.org)

**Fig. 7 Adjusting light pollution level in the View dialogue box.**

To Quit Stellarium click the  button or Ctrl + Q .

When planning science activities for students with Special Educational Needs (SEN), a number of issues need to be considered. Careful planning for inclusion using the framework for inquiry should aim to engage students in science with real purpose. Potential areas of difficulty are identified below along with suggested strategies. This list is not exhaustive, further strategies are available in the Guidelines for Teachers of Students with General Learning Disabilities (NCCA, 2007).

### ENGAGE

#### POTENTIAL AREA OF DIFFICULTY

Delayed language development/poor vocabulary/concepts

#### STRATEGIES

- Teach the language of science demonstrating meaning and/or using visual aids (material, property, strong, weak, textured, dimpled, absorbent, force, gravity).
- Have the student demonstrate scientific phenomena, for example gravity—using ‘give me, show me, make me,’ as much as possible.
- Assist the student in expressing ideas through scaffolding, verbalising a demonstration, modelling.
- Use outdoor play to develop concepts.

### INVESTIGATE

#### POTENTIAL AREA OF DIFFICULTY

Fear of failure/poor self-esteem/fear of taking risks

#### STRATEGIES

- Model the speculation of a range of answers/ideas.
- Repeat and record suggestions from the students and refer back to them.

Understanding Time and Chronology

- Practice recording the passing of time, establish classroom routines that draw the students’ attention to the measurement of time.
- Teach and practice the language of time.

Fine/Gross Motor Difficulties

- Allow time to practice handling new equipment.
- Allow additional time for drawing diagrams, making models etc.
- Give students the option to explain work orally or in another format.

Short Term Memory

- Provide the student with visual clues/symbols which can be used to remind him/her of various stages of the investigation.

### TAKE THE NEXT STEP

#### POTENTIAL AREA OF DIFFICULTY

Developing Ideas

#### STRATEGIES

- Keep ideas as simple as possible, use visuals as a reminder of earlier ideas.
- Discuss ideas with the whole group.
- Repeat and record suggestions from students and refer back to them.
- Encourage work in small group and in pairs.

Communicating Ideas

- Ask students to describe observations verbally or nonverbally using an increasing vocabulary.
- Display findings from investigations; sing, do drawings or take pictures.
- Use ICT: simple written or word-processed accounts taking photographs, making video recordings of an investigation.

### REFLECTION

- Did I take into account the individual learning needs of my students with SEN? What differentiation strategies worked well?
- Did I ensure that the lesson content was clear and that the materials used were appropriate?
- Was I aware of the pace at which students worked and the physical effort required?
- Are there cross curriculum opportunities here?
- Are the students moving on with their skills? Did the students enjoy the activity?

More strategies, resources and support available at [www.sess.ie](http://www.sess.ie)

## Curriculum Links

These are examples of some cross-curricular activities suitable for 3<sup>rd</sup>/4<sup>th</sup> class.

### English / Irish

- Write a letter to your local councillor about the streetlights in your neighbourhood. Could the design be improved to reduce light pollution to the area?
- Read stories of constellation legends: 'Stories of the Stars' book PDF  
[http://www.unawe.org/resources/books/contes\\_anglesT/](http://www.unawe.org/resources/books/contes_anglesT/)
- Read space themed news article example: 'Beaming with the light of a million suns'  
<http://www.unawe.org/kids/unawe1806/>

### P.E

- The Night You Hatched is a physical activity based around hatchling turtles at night.  
<http://www.lettherebenight.com/turtles.html>

### SESE Geography

- Geography: Study the planets, the solar system, investigate sunlight and its importance.
- Built environment: Conduct a light pollution audit of your home or street. Suggest changes to make better use of energy and to protect our natural environment.

### SESE History

- Early Christian Ireland: learn about Newgrange and how early civilisations used the night sky and sun to mark time.
- Learn about traditions associated with night sky legends in Ireland and other countries.