ASTROEDU

Peer-reviewed Astronomy Education Activities

How Many Stars Can You See at Night?

Investigate the effects of light pollution on night sky observation in your area.

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AGE

12 - 14

LEVEL

Middle School

TIME

45min

GROUP

Group

SUPERVISED

Yes

COST PER STUDENT

Low Cost

LOCATION

Small Indoor Setting (e.g. classroom)

CORE SKILLS

Planning and carrying out investigations, Analysing and interpreting data, Communicating information

TYPE(S) OF LEARNING ACTIVITY

Structured-inquiry learning, Observation based

KEYWORDS

Astronomy, Physics, Light, Pollution, Energy, Power, Constellations

SUMMARY

GOALS

To measure the negative effect of light pollution on astronomical observation.

LEARNING OBJECTIVES

Students will be able to describe the impact light pollution has on astronomical observations by showing the effect on the numbers of stars visible.

EVALUATION

Ask students to compare their results with others in the group and determine the reasons for different observation results. The work sheet can be collected and marked.

MATERIALS

Per Group of 3 Students:

- Foldable Mini-Spectrometer (PDF)
- Black card paper
- CD
- Scissor
- Smartphone
- Glue
- Black glue tape
- Worksheet
- Access to Google Drive
- Stellarium software
- Computer
- Data projector

BACKGROUND INFORMATION

Light pollution is excessive, misdirected, or obtrusive artificial (usually outdoor) light. Too much light pollution has consequences: it washes out starlight in the night sky, interferes with astronomical research, disrupts ecosystems, has adverse health effects and wastes energy.

A little more than 100 years ago, you could walk outside at night even in a city and see the Milky Way galaxy arch across the night sky. Being able to see thousands of stars was part of everyday life, inspiring artists like Van Gogh, musical composers like Holst and writers like Shakespeare. By allowing artificial lights to wash out our starry night skies, we are losing touch with our cultural heritage (e.g., what has made us who we are). We are also losing touch with what could inspire future generations.

With more than half of the world's population now living in cities, most people have never experienced the wonderment of pristinely dark skies. How do you explain the importance of what they've lost to light pollution? How can you make them aware that 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? Finally, how do you convince them that it's worthwhile to take even small steps, to help fix this problem?

(Image credit: NASA)

Effects of Light Pollution

In disrupting ecosystems, light pollution poses a serious threat in particular to nocturnal wildlife, having negative impacts on plant and animal physiology. It can confuse the migratory patterns of animals, alter competitive interactions of animals, change predator-prey relations, and cause physiological harm. The rhythm of life is orchestrated by the natural diurnal patterns of light and dark; so disruption to these patterns impacts the ecological dynamics.

With respect to adverse health effects, many species, especially humans, are dependent on natural body cycles called circadian rhythms and the production of melatonin, which are regulated by light and dark (e.g., day and night). If humans are exposed to light while sleeping, melatonin production can be suppressed. This can lead to sleep disorders and other health problems such as increased headaches, worker fatigue, medically defined stress, some forms of obesity due to lack of sleep and increased anxiety. Ties are being found to a couple of types of cancer and there are also effects of glare on aging eyes. (See text below.) Health effects are not only due to over-illumination or excessive exposure of light over time, but also improper spectral composition of light (i.e. certain colours of light).

With respect to energy wastage, lighting is responsible for at least a quarter of all electricity consumption worldwide. Over illumination can constitute energy wastage, especially upward directed lighting at night. Energy wastage is also a waste in cost and increases our carbon footprint.

The good news is that light pollution can be reduced fairly easily by shielding lights properly, by only using light when and where it is needed, by only using the amount that is needed, by using energy efficient bulbs, and by using bulbs with appropriate spectral power distributions for the task at hand.

Going further... Three Main Types of Light Pollution

Clinically speaking, the three main types of light pollution include glare, light trespass and skyglow (in addition to over-illumination and clutter). **Glare** from unshielded lighting is a public-health hazard—especially the older you become. Glare light scattering in the eye causes loss of contrast, sometimes blinds you temporarily and leads to unsafe driving conditions, for instance. **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. **Skyglow** 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 (and for the most part, unused). Shielding lights significantly reduces all three of these types of light pollution.
This exercise means to raise awareness of the impact on light pollution within students.

Preparation

The Stellarium software should be downloaded and be available to the students. It will also need to be projected. http://www.stellarium.org/en_GB/
The Stellarium FAQ contains a user-guide: http://www.stellarium.org/wiki/index.php/FAQ
As the teacher you will also require Excel to collate and plot the data.

Tip: You can obtain your geographic coordinates from google maps and enter them into Stellarium. This will give you a view of the local night sky.

To inspire the students, the teacher is encouraged to give an introduction to the concept of light pollution. The background information section contains pertinent information. It is recommended to show images of Earth viewed from the ISS provided and the time-lapse videos as well.

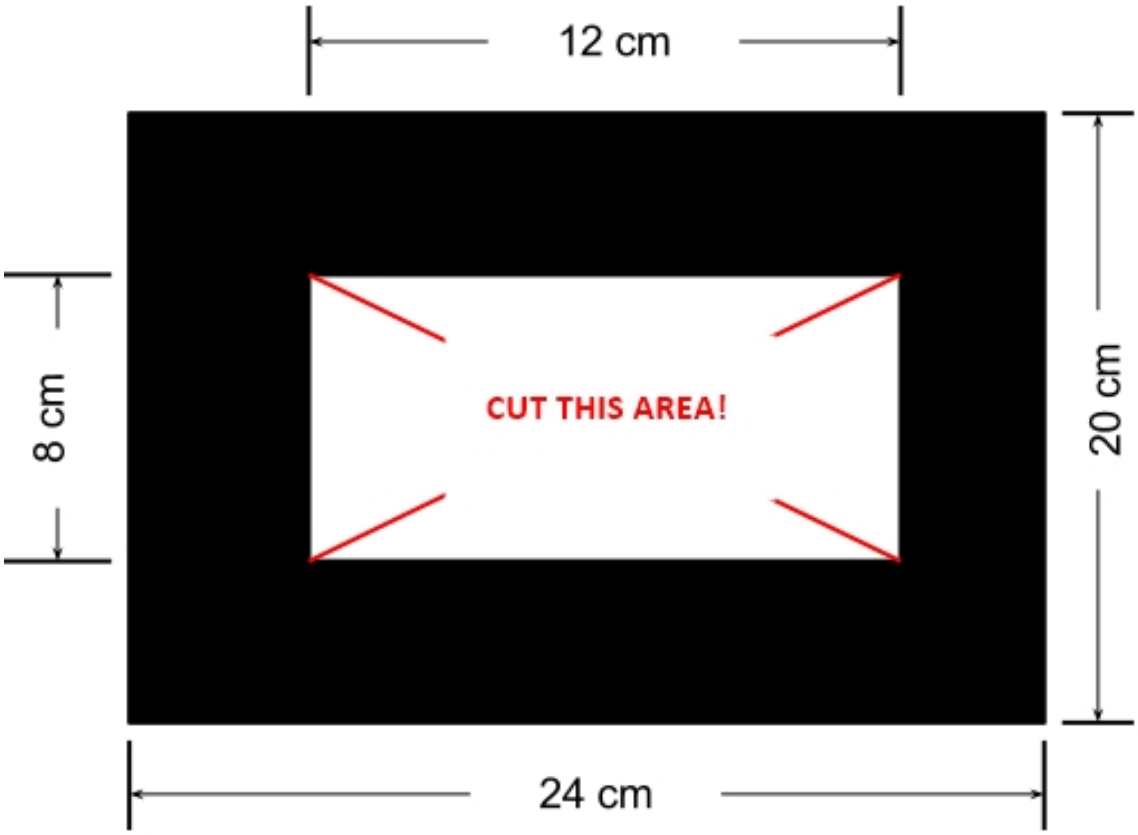
- Image: Iberian Peninsula at Night http://www.nasa.gov/content/iberian-peninsula-at-night/#.VPciDfmsX-U
- Time-lapse video: https://vimeo.com/78978601

FULL ACTIVITY DESCRIPTION

Introduce the activity to the students and ask them to observe and measure the data. *Worksheet* needs to be distributed to students prior to this class, so they can do their respective observations. It is recommended to distribute the worksheet several days before class in order to allow students to observe on a night with good weather conditions.

Step 1:

Cut out black cardboard with the dimensions shown in the figure below.



Worksheet

Step 2:

During a dark night step outside. Hold the cardboard at arm's length. Looking only at the cropped area, try to count the highest number of stars that you can see. Note down your observation (use a simple table like below).

Observation | Number of Astronomical Objects |
-|-|-|-|
1 | -
2 | -
3 | -
4 | -

Step 3:

Choose a different patch of sky and make a new observation. Write down your answer again. Repeat this step 4 times in total.

Step 4:

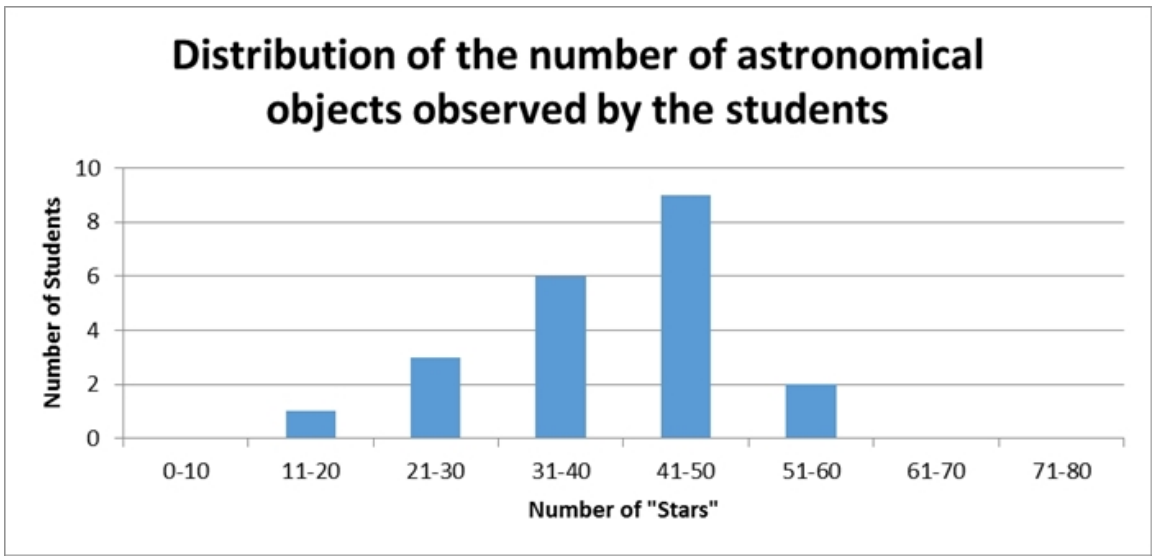
Once the students are done, collect every group's data in a table like below (*example table*):

Number of stars | Number of students |
-|-|-|-|-|-|-|
0-10 | 0
11-20 | 1
21-30 | 3
31-40 | 6

41-50 | 9
51-60 | 2
61-70 | 0
71-80 | 0

Step 5:

Plot the distribution of astronomical objects as seen in the example below.



Step 6:

Discuss with your students the following questions:

- Do we see the same number of stars in the same region?
- Why can some students observe more stars than others?
- How do these factors influence our observations?
- Is any factor more important than the others?

Why can we see so few stars at night? Because of:

- City lights (even if we are in an urban region);
- The pollution from industry;
- The clouds;
- The moonlight;
- Volcano activity;
- The atmosphere

Step 7:

Open the Stellarium software. Choose *Sky and window options* [F4]. In the "Atmosphere" area, select a value for artificial light. With the students' help, ask them to match the projected image as close to the sky night observed as possible. This can be done by counting the observed stars in a fixed area (i.e. a constellation), for example.

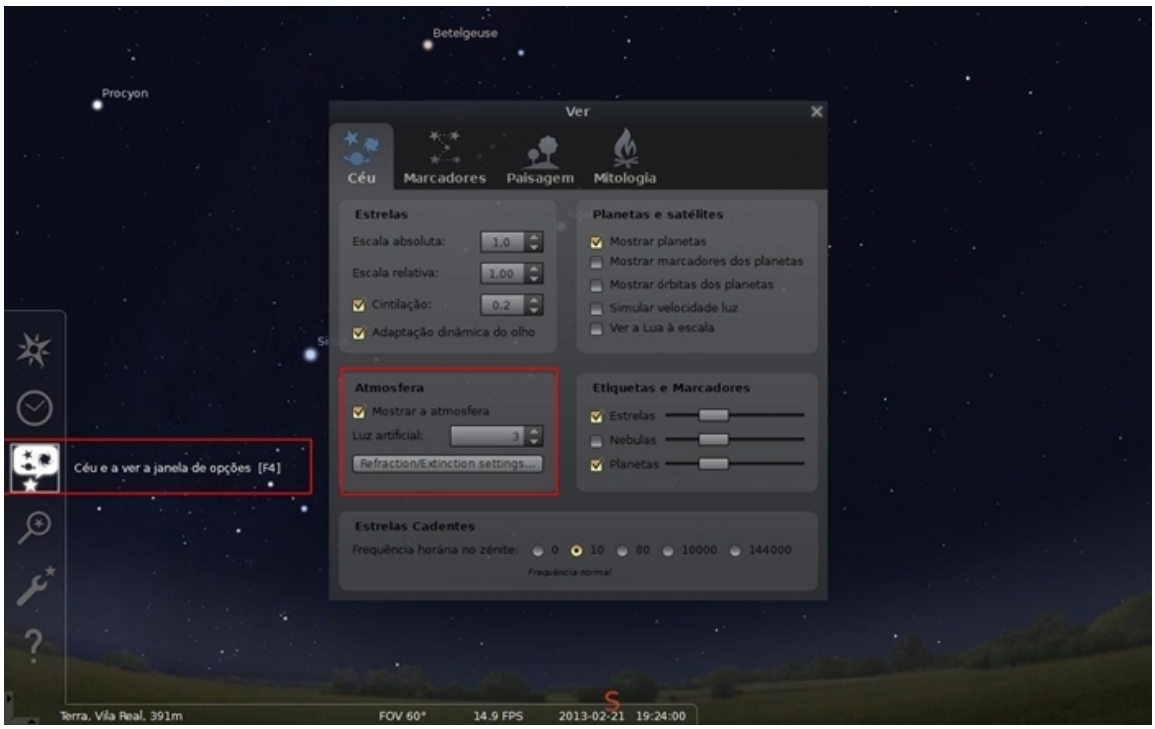
Tip: To simulate dark-sky conditions, the class-room should have the lights off and be as dark as possible.

Step 8:

Now add light to the classroom (i.e. turn on the over-head lights, open blinds) and ask students to describe what they observe.

Step 9:

This example should have illustrated the effect of light on the amount of stars we can observe.



Step 10:

Divide the students into groups of 3. Students will conduct research on the Internet to answer some of the questions.

You have been able to observe that the higher artificial light, the lower the possibility to look at our universe.

- Discuss with your teammates which are the main causes of light pollution: a) natural causes; b) anthropogenic causes. Write down your answers.

- Now it's up to you! Come up with ideas to reduce light pollution. Here are some possible answers:

Good lighting: | Bad lighting: |
-|-|-|
- Lamp is on a motion sensor, so only turns on when it is needed. | • Fixtures that are unshielded contribute to light pollution.
- Glare from bright, direct light of a lamp can create unsafe situations for drivers who do not see pedestrians, for instance. | • Light from an unshielded fixture is directed upward and will not be used where it is needed on the ground.
- Lamp is on a timer so not operating from dusk to dawn, but only when it is needed. |
- Lamp is partially shielded. Partially shielded lighting puts light where it's needed & minimizes glare and energy waste. If your lamp is shielded, you can lower the wattage of your bulb and save energy and cost. Aiming the light downward also limits the light that interferes with astronomical observations. |

- In your view which may be the best places to observe the Universe? Justify your answer.

Step 11:

As a conclusion, show the image that follows (you can provide the address for the students to explore the simulations in the classroom or at home: http://www.need-less.org.uk/)

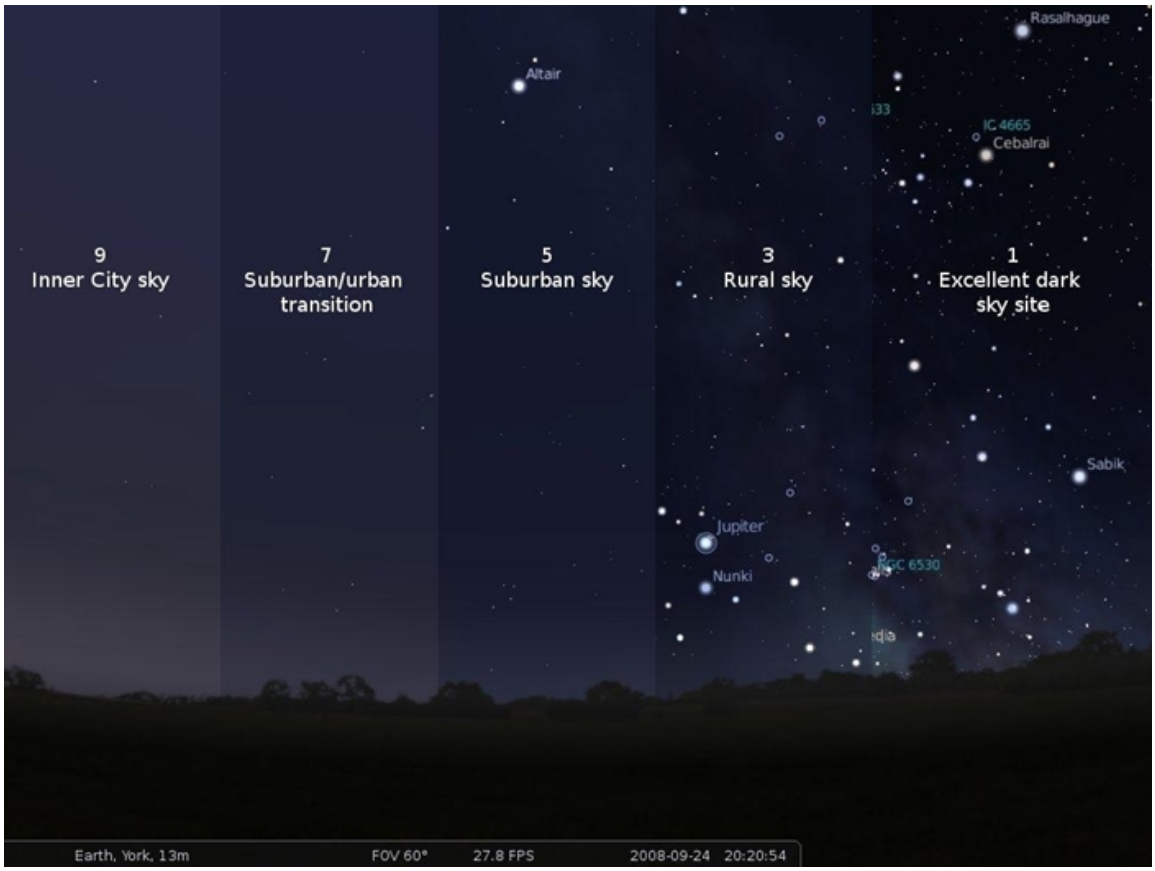


Image credit: Need-Less

CURRICULUM

Country	Level	Subject	Exam Board	Section
UK	KS3	Geography	-	Geographical skills and fieldwork: use fieldwork in contrasting locations to collect, analyse and draw conclusions from geographical data, using multiple sources of increasingly complex information.
UK	KS3	Geography	-	Human geography: understand, through the use of detailed place-based exemplars at a variety of scales, the key processes in: population and urbanisation; and the use of natural resources.
UK	GCSE	Physics	OCR A	P1.1 The Earth in the Universe: 13. understand that light pollution and other atmospheric conditions interfere with observations of the night sky.

Country Level	Subject	Exam Board	Section
UK GCSE	Astronomy	Edexcel	1.1d Planet Earth: describe some of the major causes of light pollution and demonstrate an understanding of why it is undesirable to astronomers.

ADDITIONAL INFORMATION

- The Lost World of Starry Night: How many stars can you see at night? https://drive.google.com/file/d/0B6572_Wx-YOKQlcxcHF3YktqYms/view?pli=1
- Light Pollution - The End of Night? http://goo.gl/gBUcT4
- Light Pollution Taking Toll on Wildlife, Eco-Groups Say http://goo.gl/C0h7qd
- Light Pollution and Ecosystems http://goo.gl/DQMxWG
- Why We Need To Sleep In Total Darkness http://goo.gl/dK1ATH

CONCLUSION

The students conduct an investigation by working together and they explain what causes light pollution and present the results to the public.

ATTACHMENTS

- Foldable Mini-Spectrometer PDF

CITATION

Gonçalves, J.; Zaunig, F., 2016, *How Many Stars Can You See at Night?*, astroEDU, doi:10.11588/astroedu.2015.3.81531

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