

Outcomes from the IYL2015 Quality Lighting Teaching Kit Program: Reaching for the Stars

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for the International Symposium on Education in Astronomy & Astrobiology

Photo Credit: James Lowenthal



Today's Talk

- The motivation for the project
- Some background on the project
- The initial evaluation results of the project
- Other light pollution education projects
- A Call to Action as a Community



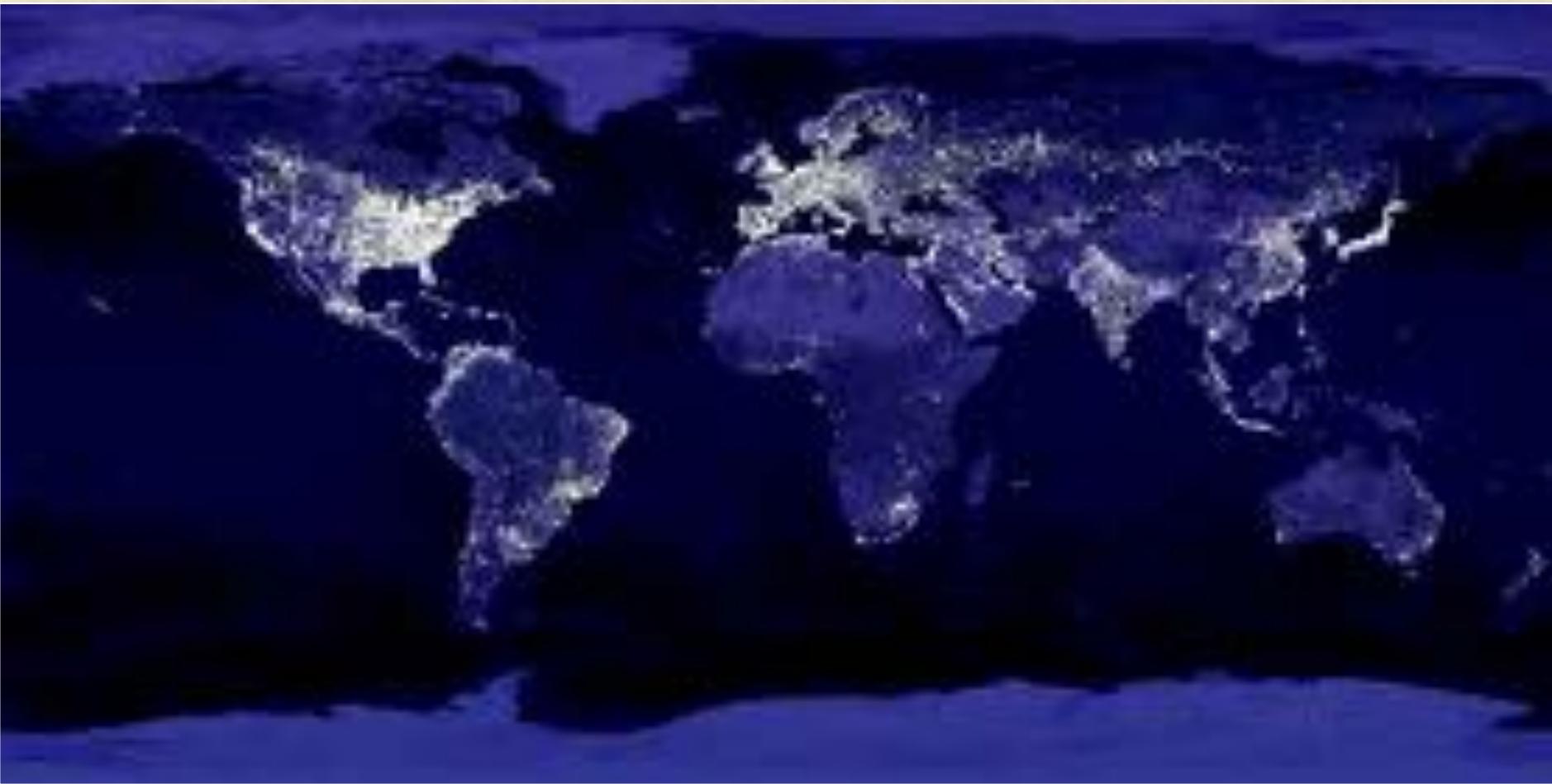
Imagine enjoying this starry sky every night



London – 1880's
first electric street lights



The World 130 Years later –
Our Global Challenge ...



Light Pollution affects...

Astronomical Research



Energy, Safety & Cost



Human Health



Wildlife



A Quote to Ponder...

``When teaching astronomy to university students, I routinely ask how many people have seen the Milky Way? For students in Hawaii, I am now finding that more than half of my classes have never seen the Milky Way. This fraction seems to be increasing at an alarming rate.”

Richard Wainscoat, astronomer,
professor & dark skies advocate

Stargazing in Honolulu, Hawaii, USA



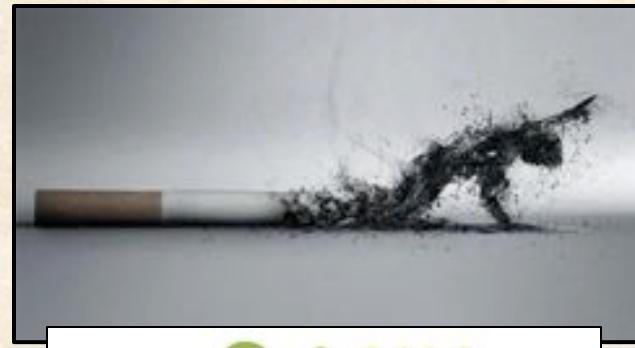
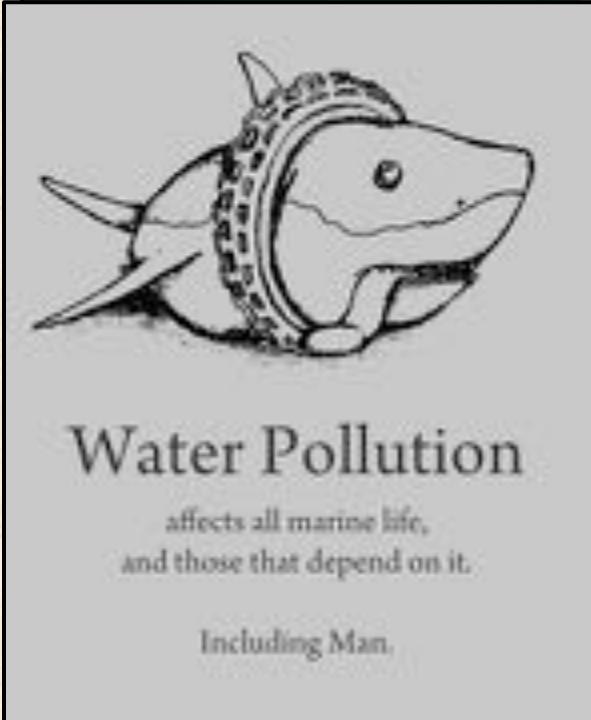
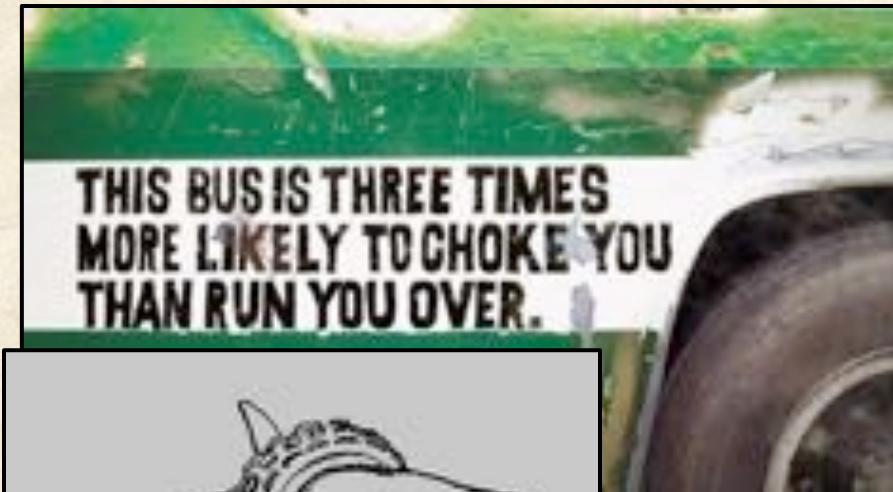
Babak Tafreshi, TWAN

The Main Challenge

- How do you change the mindset of a society that is used to turning night into day? How do you convince them they have lost something of value?
- You focus on educating the next generation of leaders and change makers on why understanding the effects of and solutions to light pollution is important.



Successful-ish Anti-Pollution Campaigns



Quality Lighting Teaching Kit: Intro

- One of 5 International Year of Light Projects funded by the IAU.
- Produced by U.S. National Optical Astronomy Observatory's EPO.
 - Previously: Dark Skies Rangers, Dark Skies Africa, Dark Skies Yuma
- Designed as a kit around 6 **problem-based learning scenarios**.
- Launched late 2015 to 92 partners in 32 countries.
 - OSA, SPIE, CIE, IDA & IAU Office of Astronomy for Development



OSA = Optical Society

IAU = International Astronomical Union

EPO = Education and Public Outreach

SPIE = Society of Photo-optical Instrumentation Engineers

CIE = International Commission on Illumination

IDA = International Dark-Sky Association



Quality Lighting Teaching Kit: 6 Activities

E

Glare
(Aging Eyes)

F P

2 20/100

T O Z

3 20/70

L P E D

4 20/50

P E C F D

5 20/40

E D F C Z P

6 20/30

F E L O P Z D

7 20/25

P E R R O T E C

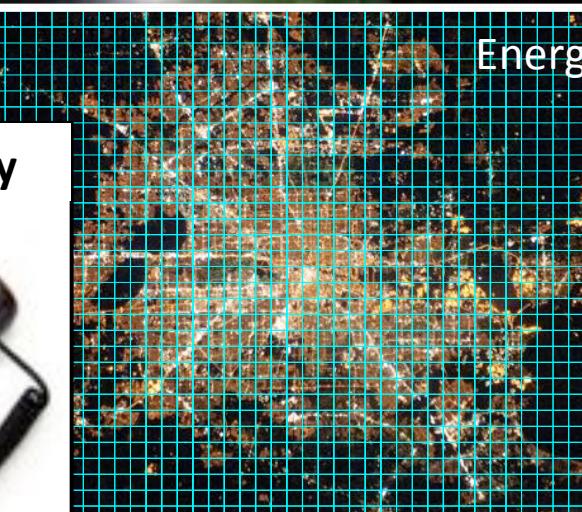
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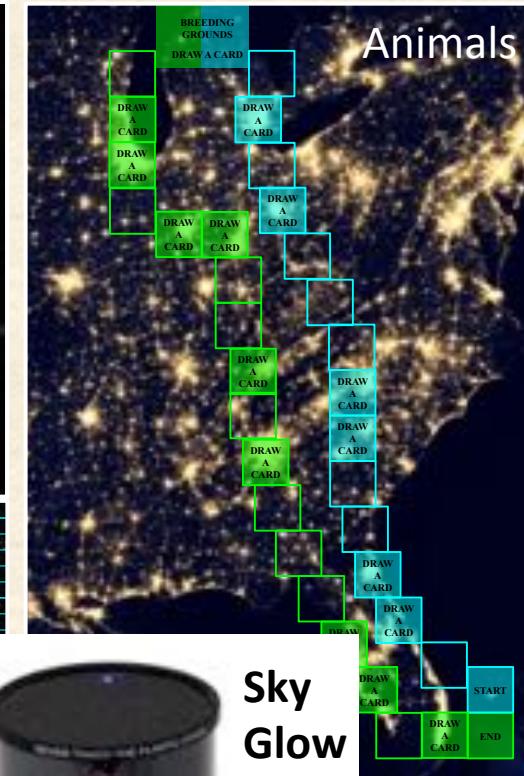
Light Trespass



Safety



Energy



Animals



Sky
Glow

Example of a QLT Kit Activity: Light Pollution & Safety

- With a lux meter, measure lighting levels in different situations with different lights.
- Determine the lowest level of light needed function.
- Compare results with Public Lighting Standards.
- Determine what number a lux meter should read to have enough light to see, but not to over-light an area. How might you design a light to do this? Do all parts of the city need to be lit the same amount?



Light Pollution and Safety

Safety

- Does more light mean more safety? Not necessarily!
- While we need light to see at night, bad lighting can be just as unsafe as no lighting at all!
- Glow from lights makes it harder to see, especially while driving.
- Look at the two sets of images to the right. Can you see the person in the left pictures? What about in the right pictures? What's different about the lights in each scene?



Crime

- Lights which are glaring or overly bright can be easy hitting spots for burglars.
- Lights which are poorly shielded or glaring can create shadows where people can hide.
- People feel more safe in the light. But criminals can hide in the excessive light or shadow.
- Roughly half of all crimes are committed during the day time. Outdoor lighting by itself does not keep you or your property safer than little or no light.

Public Lighting Standards

- The table below lists minimum recommended lux or brightness levels for outdoor lights in different areas. The bigger the number, the brighter the area. Intersections of streets are lit about 2X the rest of the street.
- The Mayor will have a more detailed table of brightness levels for indoor lighting as well as for the outdoors.

Area	Brightness Level (lux)
Suburban Streets	6
Highway	8
Major Street	11
Parks, Schools, Buildings	11
Parking Lot	22
Sports Stadiums	500

Lighting Responsibly

- Responsible, safe lights should light up the ground without being glaring.
- Glow is caused by an overly bright, exposed bulb.
- Lights should be task-oriented, meaning that they have a specific purpose.
- How much light is actually needed? What is the minimum amount of light needed to see? Does the light cause shadows?



Different amounts of shielding lights (move to fully shielded) put light where you need it and sometimes where you don't. When can you see the person?

Key Ideas

- Light pollution and crime
- Light pollution and safety
- Public lighting lux levels

Now Try This!

- Take out the lux meter and read the instructions on how to use this brightness measuring device.
- To calibrate the lux meter, keep the cap on the sensor and turn the lux meter on. What should the reading be? Calibrate before each set of measurements. Always make multiple measurements per location. Record readings after each measurement, noting all pertinent details.
- You will be exploring ranges of lighting levels for different locations and deciding what minimum light levels are needed to accomplish tasks in those areas and still stay safe.
- Take the lux meter cap off to measure the brightness of a regularly lit classroom. Then make the classroom as dark as you can and repeat the measurement. Then measure the book light turned on in the dark room. Always put the meter at the point of interest. For example, in a dark classroom, the lux meter may be on the desk next to the book light while a student is reading.
- Take measurements in the school's restroom, library and main office to see how they compare with standard light levels of 200, 300 and 500 lux, respectively. Take measurements outside in sunlight (1000 lux).
- If you can visit a home, a restaurant, a supermarket, a hospital or places in the list on the left with the lux meter, take a few measurements per area.
- If not, perhaps the Mayor can gather extra lights and with a dark classroom, simulate the lighting levels corresponding to one or more areas listed in a table the Mayor will provide. For example, an operating room at a hospital is between 750 and 1500 lux.
- Compare your measurements with the Mayor's provided list of light levels and the list to the left. Determine what numbers or range of numbers a lux meter should read to have enough light to see and stay safe, but not to over-light each area. How might you design a light to do this? Do all parts of the city need to be lit the same amount?
- Create a powerpoint, a video, or a poster in which the issues, problem(s), and your resulting recommendations are presented to the Mayor.



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Contaminación lumínica y seguridad

Seguridad

- ¿Más luz significa más seguridad? ¡No necesariamente!
- Aunque necesitamos luz para ver en la noche, ¡la mala iluminación puede ser tan peligrosa como no tener iluminación en absoluto!
- El resplandor de las luces hace que sea más difícil ver, en especial mientras se conduce.
- Mira los dos conjuntos de imágenes a la derecha. ¿Puedes ver a la persona en la imagen de la izquierda? ¿Y en la imagen de la derecha? ¿Qué diferencia tienen las luces de cada escena?



Crimen

- Las luces que resplandecen o que son demasiado brillantes se pueden convertir en un escondite fácil para los ladrones.
- Las luces que se encuentran mal protegidas o muy deslumbrantes, pueden crear sombras en donde la gente se puede ocultar.
- La gente se siente más segura con la luz. Sin embargo, los delincuentes pueden esconderse en el exceso de luz o en la sombra.
- Aproximadamente la mitad de los delitos se cometen durante el día. La iluminación de exterior por sí misma no te mantiene más seguro a ti o a tu hogar.

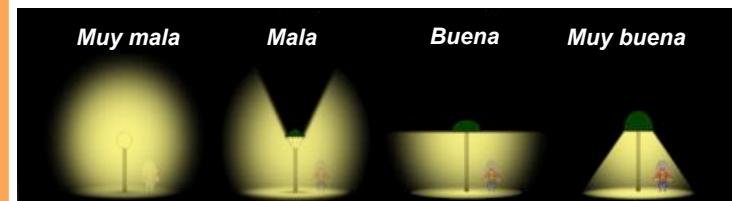
Estándares de iluminación pública

- La tabla debajo entrega una lista del mínimo necesario de luz o del nivel de brillo recomendado para las luces al aire libre en distintas áreas. Cuanto mayor sea el número, más brillante es la zona. Las intersecciones de calles se iluminan el doble que el resto de la calle.
- El alcalde tendrá una tabla más detallada de los niveles de brillo, tanto para la luz de interior como para la luz al aire libre.

Área	Nivel de brillo (luz)
Calle suburbana	6
Carretera	8
Calle principal	11
Parques, escuelas, edificios	11
Estacionamiento	22
Estadio deportivo	500

Iluminación responsable

- Las luces seguras, instaladas con responsabilidad deben de iluminar el suelo, sin ser encandilantes.
- El encandilamiento se produce, por una ampolleta expuesta con exceso de brillo.
- Las luces deben estar orientadas a sus tareas, o sea deben cumplir con su propósito.
- ¿Cuánta luz se necesita en realidad? ¿Cuál es la cantidad mínima de luz para poder ver? ¿La luz provoca sombra?



Diferentes tipos de protección para las luces (ninguna luz protegida completamente) pon la luz donde la necesites y en ocasiones donde no. ¿Cuándo se puede ver a la persona?

Ideas Clave

- Contaminación lumínica y seguridad

- Contaminación lumínica y crimen
- Luz pública y niveles de luz

¡Ahora intenta esto!

- Saca el luxómetro y lee las instrucciones sobre cómo utilizar este dispositivo de medición de brillo.
- Para calibrar el luxómetro, mantén la tapa en el sensor y prende el luxómetro. ¿Cuál debería ser la lectura? Calibra antes de cada serie de mediciones. Realiza siempre varias mediciones para cada ubicación. Registra las lecturas después de cada medición, no todos los detalles pertinentes.
- Podrás explorar los rangos de niveles de iluminación para diferentes lugares y decidir cuáles son niveles mínimos de luz necesarios para llevar a cabo sus labores en esas áreas y aun así mantenerse seguro.
- Retira la tapa del luxómetro para medir el brillo de la sala iluminada como es regularmente. A continuación, haz que la sala esté tan oscura como sea posible y repite la medición. Luego, mide el booklight mientras está encendido en la sala oscura. Pon siempre el medidor en el punto de interés. Por ejemplo, en la sala a oscuras, el medidor de luz puede estar en la mesa al lado del booklight donde está leyendo un estudiante.
- Realiza las mediciones en el baño, la biblioteca y la oficina principal de la escuela para ver cómo se comparan con los niveles de luz estándar de 200, 300 y 500 lux, respectivamente. Toma mediciones fuera a la luz del sol (1000 lux).
- Si puedes visitar un hogar, restaurante, supermercado, hospital, o cualquiera de los lugares de la lista con el luxómetro, toma unas cuantas mediciones por área.
- De no ser posible el punto anterior, quizás el Alcalde puede reunir luces adicionales y con la sala a oscuras, simular los niveles de iluminación correspondientes a una o más áreas que figuran en una tabla el Alcalde proporcionará. Por ejemplo; una sala de operaciones de un hospital tiene entre 750 y 1.500 lux.
- Compara tus mediciones con la lista proporcionada por el Alcalde sobre niveles de luz y la lista de la izquierda. Determinar qué números o rango de números un luxómetro debe leer para tener luz suficiente para poder para ver y mantenerse a salvo, pero no a un exceso de luz de en cada área. ¿Cómo podrías diseñar una luz para hacer esto? ¿Todos los lugares en la ciudad deben ser iluminados con la misma cantidad de luz?
- Crea un powerpoint, video o poster presentando los problemas de iluminación y tus recomendaciones para resolverlos. Luego presentártelo al alcalde.



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Quality Lighting Teaching Kit: Features

- Adaptable to age group, venue and time allotment.
- Can be used in classrooms, afterschool programs, museums and national parks
- Can be done one activity to a group and report out, or as rotating through 6 stations.
- Translated into Spanish



AURA



SPIE. cie



The PBL Sequence for the Activities

- Teacher = Mayor of the city.
 - Citizens have complaints about lighting.
 - Students get into task groups to solve six issues (on light trespass, night sky, glare, animals, safety or energy)
 - Review the poster on their issue.
 - Try the “Now Try This” activity using kit materials.
 - Do online research with key phrases from poster.
 - Brainstorm and test solutions to issues.
 - Present findings to the mayor (teacher) & class.
 - Discuss city’s overall plan of action.
- (Steps can be adapted or omitted.)



Quality Lighting Teaching Kit: Resources

- Tutorial videos for each activity on NOAO EPO YouTube channel.
- Google+ Hangouts provide Q&A for activities.
- Posters provide background for each issue.
- Kit supplies provide all the resources to do the activities.
- Activities provide understanding of the issues through experimentation.
- Capstone presentations from the student task force groups provide solutions to the real-life issues.
- Pre- and post-surveys for students → learning outcomes; post-survey for instructors → improvements



Facilitator Data

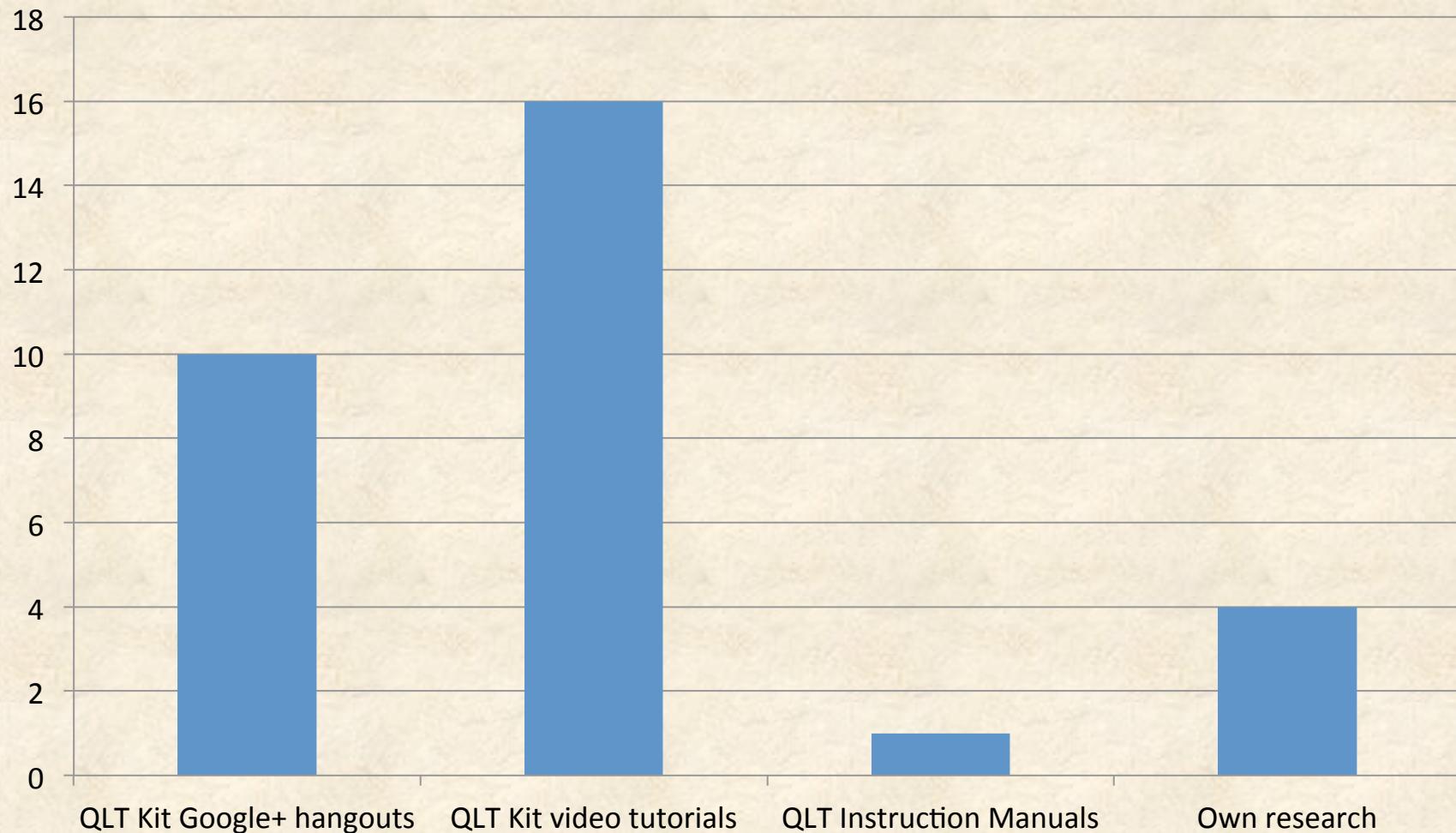


OSA & SPIE Student Chapter from Tucumán, Argentina as facilitators

Facilitators (n=21) from 9 locations

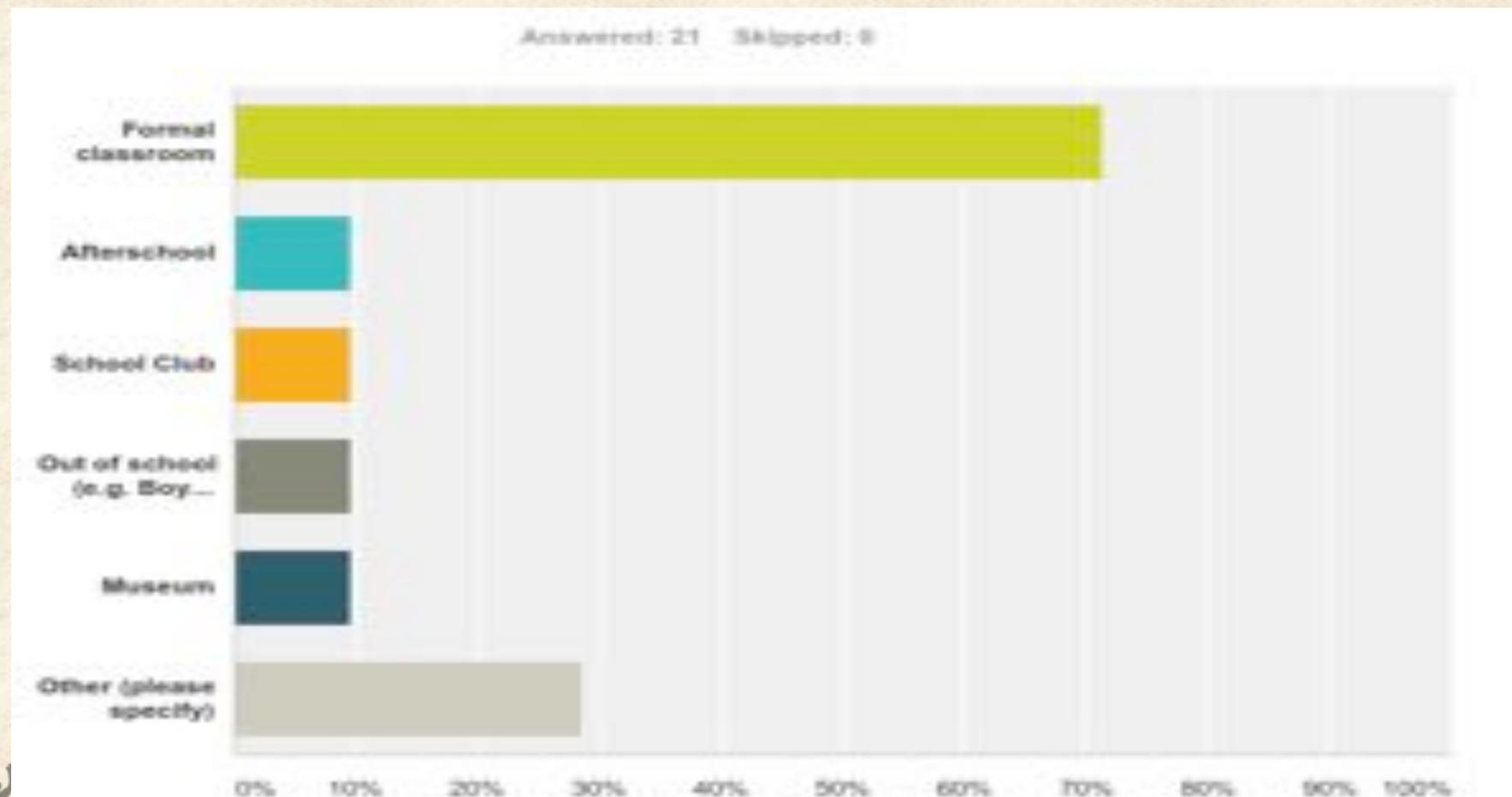


Methods of training used to prepare facilitators

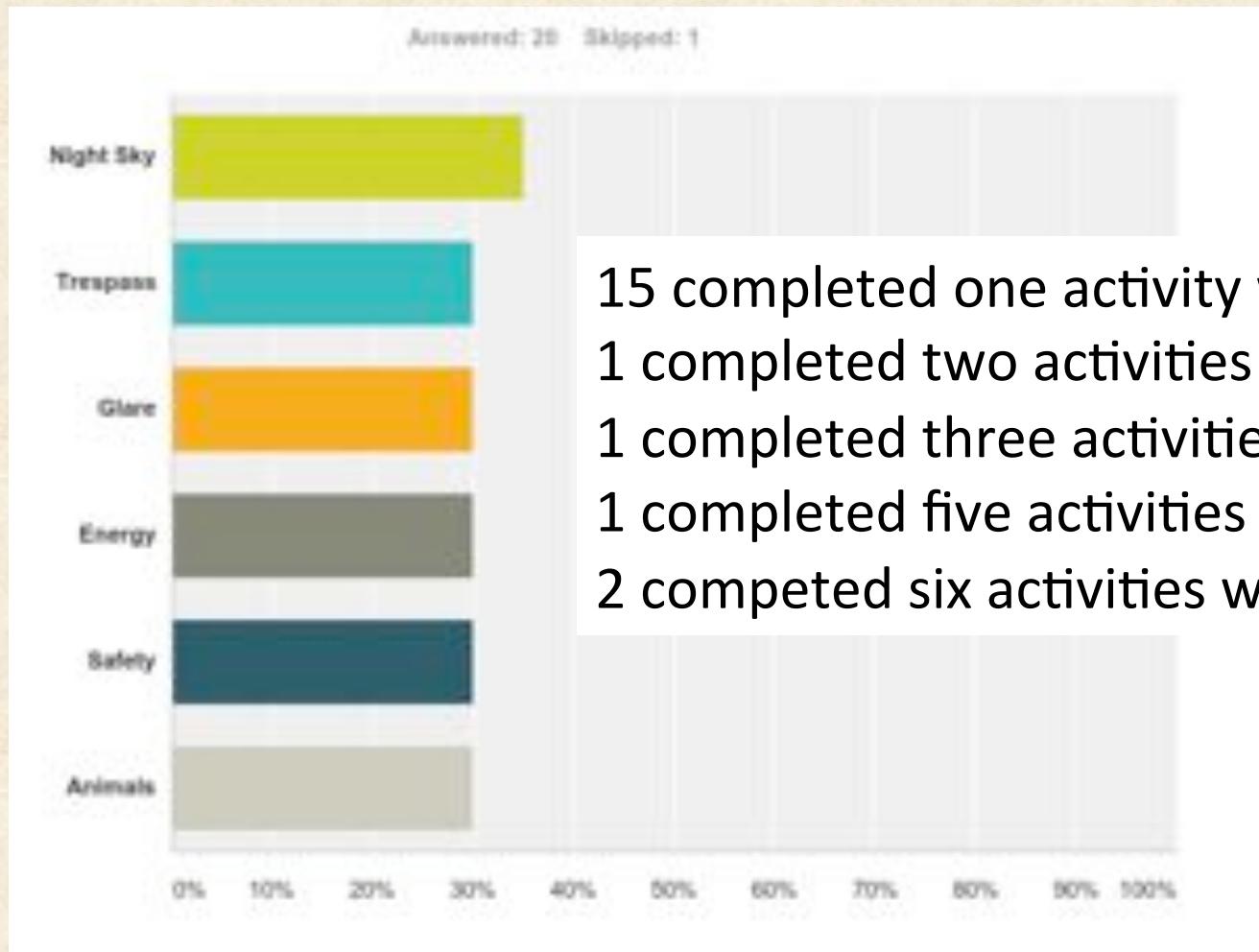


In which settings where learners engaged?

- Facilitators reported directly working with 2141 learners



In which of the activities were learners engaged?



15 completed one activity with learners
1 completed two activities with learners
1 completed three activities with learners
1 completed five activities with learners
2 completed six activities with learners



Length of experiences

- For sites who implemented one activity – the length of time ranged from 30 minutes to 2 hours
- For implementing two activities, 1.5 hours
- For implementing 3 activities, 2 hours
- For implementing five or six activities – variable, either breaking up into groups for several hours or engaging students every week over a semester



Examples of implementation

- “The full group was large so I explained light pollution, explained each QLT task and how it was relevant and what each task required as an outcome and then split the group into sub-groups to work on each task and develop a presentation.”
- “Students read in detail the information on the posters, expressing their doubts or comments, In a continuous feedback. Later the students analyzed the materials and followed the activities proposed in the poster, at the same time that they expressed their conclusions, and the information they would then share.”





Lessons were adapted to local conditions

- “The students spent about an hour for the light pollution and energy activity. Students made use of the value of average electricity tariff cost [locally] for their energy calculation instead of the value of \$0.08 per kWh stated on their worksheets. The reason was for us to localise the exercise to our region. We made use of the light pollution and energy kit. The students were able to deduce that the electricity consumption, cost and carbon footprint is a function of the type of bulbs used for our lighting.”



Feedback on activities

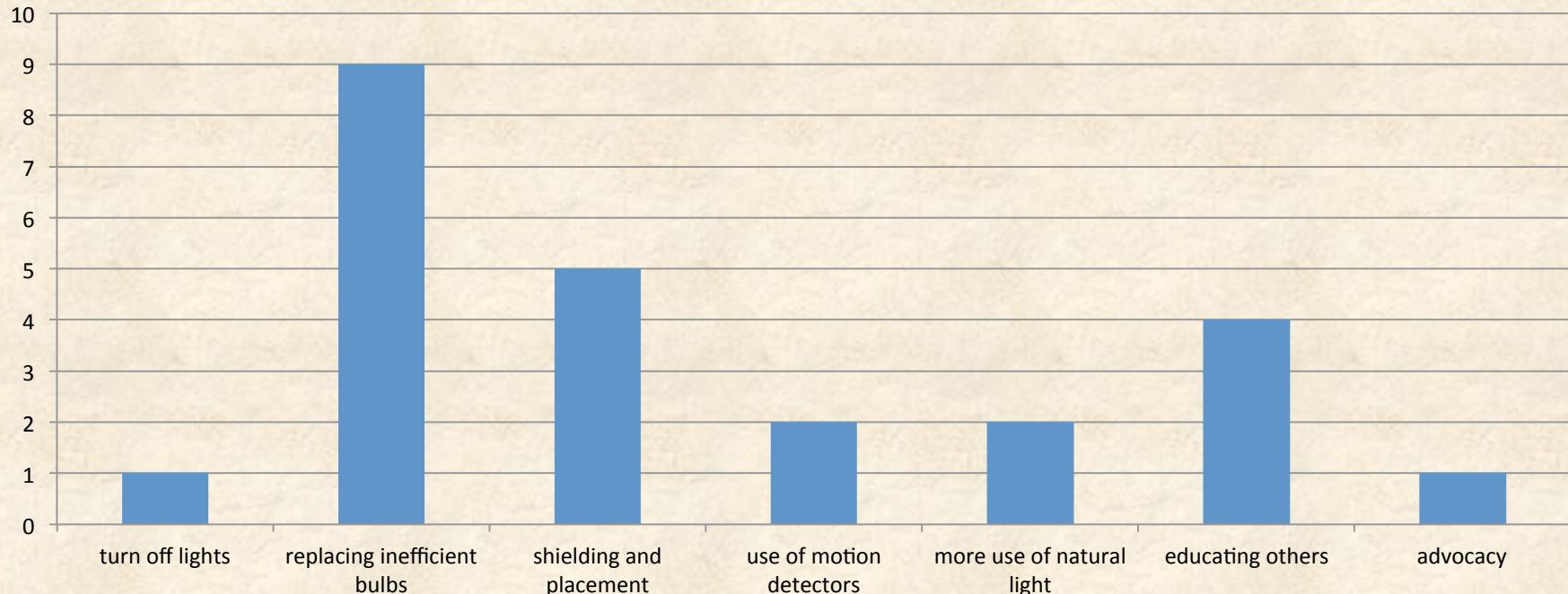
- Generally positive feedback

“Some public and students have never thought about these issues before. Ultimately the public and students are more informed and can make better decisions about their own actions in their environment. Some of the students and public are very interested in their environment and want Councils and Government to do more to protect our environment. Empowering the students and public with knowledge leads to a more proactive community when it comes to practical outcomes.”



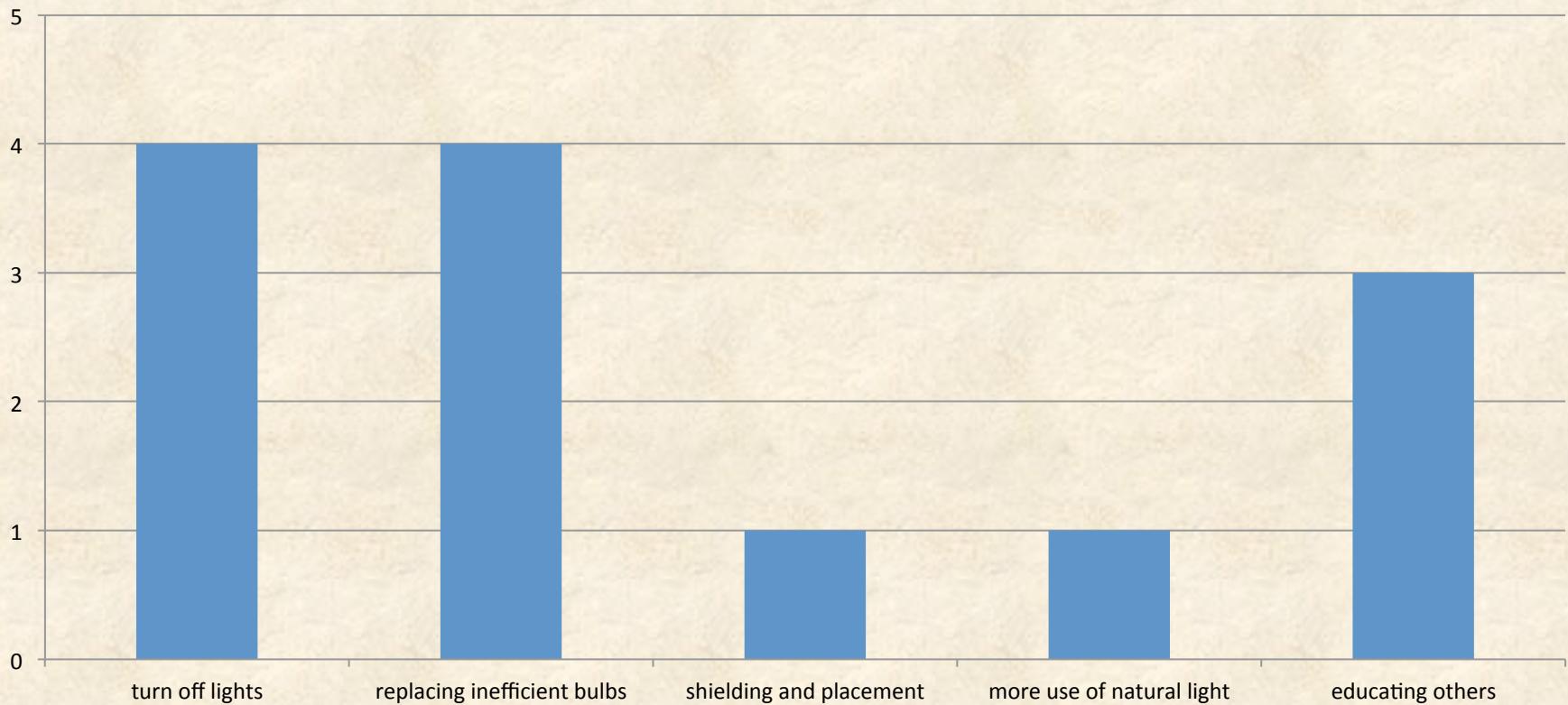
Changes to behavior

- Personal changes planned by facilitators based on lessons learned from the activities



Changes to behavior

- Personal changes planned by students based on lessons learned from the activities



Student Data

N=120

114 pre and post paired surveys
6 post surveys only



Survey for students

- Asks students:
 - Their age
 - Describe, in their own words, what light pollution is (pre and post)
 - Discuss what the main causes of light pollution are
 - Talk about the impact of light pollution on humans and other living animals
 - Which activities they participated in
 - Discuss solutions they came up with to light pollution
 - Talk about changes they might make in their own lives related to what they learned
 - Give feedback on the activities/lessons



About the students who completed surveys

- 12 – 19 years old
- Located in five different countries from around the world
- Surveys completed online (Survey Monkey) and on paper in multiple languages (English and Spanish)



Reported Number of Students from the 9 locations (n=2141)



Student Surveys (n=120) from 5 locations



Student Surveys

- USA (Hawaii) Pre Post, Animals
- Argentina, Pre Post, Night Sky
- Argentina, Pre Post, Animals
- Argentina, Pre Post, Trespass
- Argentina, Pre Post, Energy
- Nigeria, Pre Post, Night Sky
- Italy, Post, Night Sky
- India, Post Night Sky, Safety, Glare, Light Trespass, & Energy



Changes in Student Knowledge Pre to Post

- Pre surveys showed lack of awareness of light pollution and other misunderstandings of the concept (not encountered)
- Examples of pre responses
 - “light pollution means when there is outbreak or sparking on an electric wire or transformer to cause damages”
 - “light pollution can be defined as the process whereby light is being used in an unexpected way that it is misused.”



Changes in Student Knowledge Pre to Post

- In general post surveys showed growth of awareness of light pollution
- Paired examples of post responses
 - “light pollution is the process by which light is being wasted up to the sky to reduce the number of stars seen”.
 - “light pollution can be defined as having too much light in an environment that is excess light.”





Students' Knowledge about Light Pollution and Related Issues

- After engaging in Night Sky activity, youngest students (12 years old) achieved basic understanding of light pollution – e.g. too much light at night caused by human made lights
- Light pollution makes it so humans can't see stars at night, waste of energy
- Able to articulate solutions; motion detectors, light shielding, use more efficient types of lights



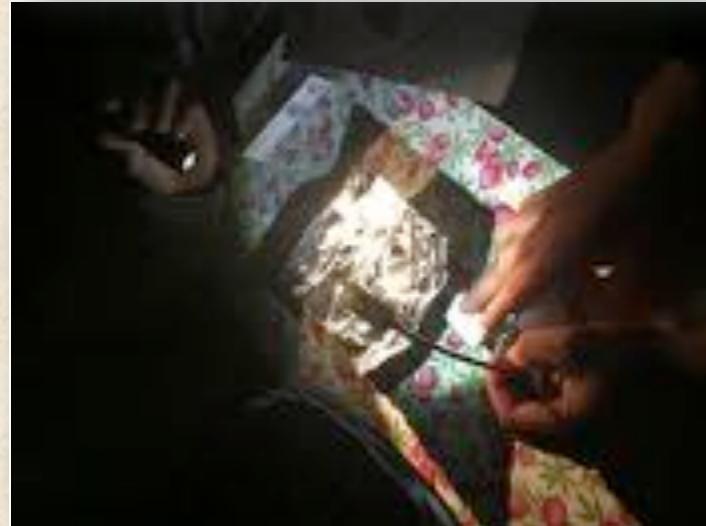
Students' Knowledge about Light Pollution and Related Issues

- Older students who engaged with more than one activity – able to express more advanced understandings
- Causes “Improper installation of lights of sign boards of shops, improper installation of street lighting, open light masts of houses, decoration lighting during marriages, and festivals”
- Impact “On humans: sleepiness, drowsiness, lack of deep sleep due to lights. Animals: observed that cows are wandering for search of food even in night.”



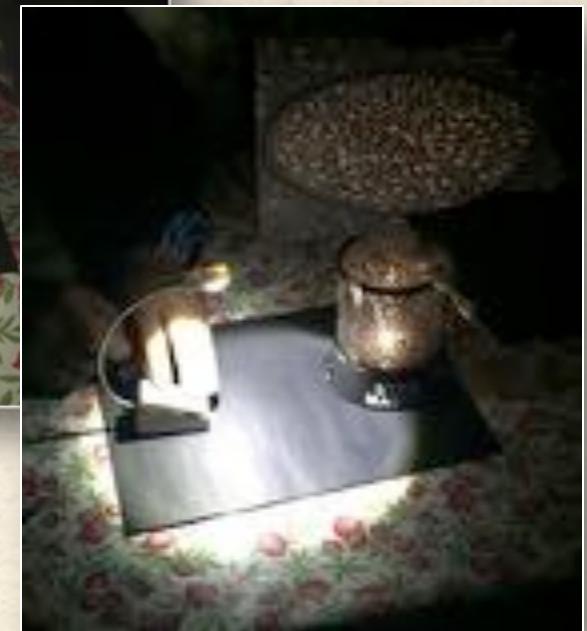
Post surveys, continued

- Some students' misconceptions remained after activities
 - “light pollution can be defined as the excessive use of light whereby carbon footprint are released into the sky to weaken the ozone layer.”



Student Strategies to Deal with Light Pollution

- Turn off lights when not in use, use dimmers, light shielding, changing the types of light bulbs to be more efficient
- Students expressed wanting to make changes in their lives but acknowledged that both parents and government actions may pose barriers to making large changes.



What students liked

- Hands-on activities/games
- Learning new information
- Information that they learned that was relevant to them (e.g. ways to save energy, save money, contribute to human health)



Suggestions from Students

- Some students reported that they wanted to spend more time on activities
- Suggestions about additional topics they wanted to learn about including other pollutions
- Want more people to learn about topics they learned about





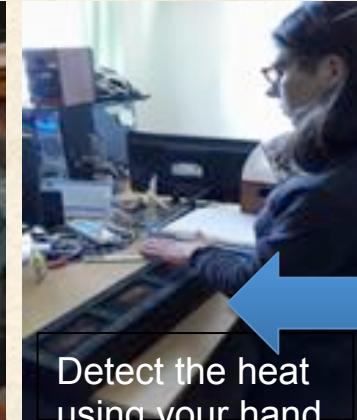
Other Programs of Interest on Light Pollution Education



Network for Astronomy School Education

Light Pollution Activities (IAU C.C1)

- (Sky) Glow (compare demo with photos)
- Consumption-Energy
- Chemical composition of the public luminaries
- Different Spectra using NASE or cell phone spectrometer
- Street Lights: Composition



Detect the heat using your hand.



Incandescent



Dark Skies Rangers Activities that provide a foundation (12 and younger) (IYA2009)



- **Explorer**
 - Light Shielding Lab
 - Spectra of Lights
 - Outdoor Lighting Audit
- **Protector**
 - On the Night You Hatched (Role Playing Sea Turtles)
- **Advocate**
 - Constellations at Your Fingertips
 - How Light Pollution Affects the Stars
 - Globe at Night campaign
- **Ranger** (Students present results.)
- At www.globeatnight.org/dsr/





DRAWING & GAME DESIGN CONTEST

In 2015 come celebrate
the night sky with us!



In Portugal:

Hundreds of students
participating in contests
producing: calendars,
games and videos

Lets turn off the lights to light up the stars!

GLORY STARS

100

START

DARK SKIES RANGERS



Globe at Night: An Effective Worldwide Program



What: Invites citizen-scientists to measure their night sky brightness and submit their observations to a website from a computer or smart phone: www.globeatnight.org

Who: people aged 8 and up

When: 10-day campaigns each month (no Moon in late evening)

Where: Anywhere; everywhere!

How: 23,000 measurements from 104 countries during IYL! Over 168,000 measurements from 180 countries in the last 11 years.

Cities at Night. Creating a world map of the night using ISS color pictures

Citizen science project with 3 steps to navigate through half a million pictures inside the NASA database:

- *Dark Skies* and *Nightknights* apps to classify the photos as auroras, stars, the spacecraft, cities...
- *Lost at night* app to identify a specific city shown in the photos
- *Night cities* app to select 3 recognizable places of a city so it fits in the puzzle and eventually the world map.



www.citiesatnight.org  @cities4tnight



Light Pollution Initiatives partnering with STARS4ALL



Light Pollution Outreach
Organizes Light Pollution Collective Awareness Activities.



Loss of the Night
Monitoring Light Pollution from any location by using mobile phones.



My Sky At Night
Present measured data of nightscape brightness back to the citizens.



Intercomparison Campaigns
Organize meetings to compare methods to measure sky brightness.



NixNox
Find and characterize places where people could go to enjoy dark and starry skies.



Globe at Night
Citizen-science campaign to raise LP awareness by gathering night sky brightness measures.



STARSthruQL
With this kit young students can explore the concepts of quality lighting through six activities.



Buometria Participativa
Raising awareness on the issue of LP, collecting quantitative data and promoting participatory processes.





The “Mother of Light Pollution Education”, Dr. Margarita Metaxa,

who after more than 25 years is still
teaching students about light pollution
mitigation.



Calls for Action and Recommendations



I often think that the night is more alive and more richly colored than the day.

Vincent Van Gogh

- There is importance in carrying out programs and initiatives worldwide aimed to inspire and motivate children and educators to enjoy and to care as guardians for the starry, night skies and its associated cultural values.
- As a global community, we can solve these challenges.
- You are cordially invited to come over to the dark side of astronomy and get involved...



Contact Information

- Questions?

Contact QLT Kit program and Globe at Night director, Connie Walker, at cwalker@noao.edu.

- Websites of interest:

- Quality Lighting Teaching Kit (videos):

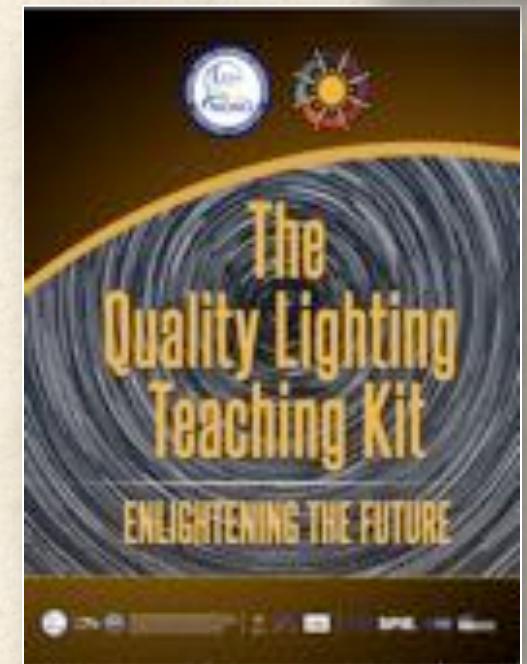
www.noao.edu/education/qltkit.php

- Globe at Night citizen science campaign:

www.globeatnight.org

- International Dark-Sky Association:

www.darksky.org



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ida INTERNATIONAL DARK-SKY ASSOCIATION

