Chicago Teens as Light Pollution Researchers and Advocates

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Abstract

The Adler Planetarium's Teen Programs engages hundreds of young people in authentic STEM experiences each year. Several of our programs focus on artificial light at night (ALAN), a critical environmental, health, ecological and astronomical issue. Our work in ALAN Community Advocacy and Education began in 2015 through Youth Organization for Lights Out (YOLO), a bilingual program in English and Spanish based in Chicago's predominantly Mexican and Mexican-American Little Village neighborhood. YOLO program participants use tools to collect and analyze light pollution data, attend field trips to local and state dark sky sites, facilitate telescope viewing at the Adler and in their community, and develop prototype solutions and action plans to increase awareness of light pollution's local effects in Chicago. Programs focused on Instrumentation and Research grew out of the Adler's educational high-altitude ballooning program, Far Horizons. In 2018, Far Horizons astronomers and engineers began developing Mission NITELite (Night Imaging of Terrestrial Environments), a high altitude balloon-based light pollution mapping mission along with undergraduate interns. To complement NITELite, Far Horizons designed GONet (Ground Observing Network), a low-cost all-sky imaging system to measure sky quality at night as part of its Stratonauts teen program. In 2019, high school students helped design, test, and build 50 GONet units as a potential new standard for worldwide ALAN monitoring. In 2020, Adler teen interns are working with the Cook County Forest Preserves to quantify regional sky quality with GONets in support of an application for an Urban Night Sky Place designation from the International Dark-Sky Association. Reflecting the collaborative nature of science, teens in the Instrumentation and Research programs partner closely with peers in the Community Advocacy and Education programs, learning from one another's perspective while undertaking joint projects.

Chicago Teens as Light Pollution Researchers and Advocates

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BACKGROUND

The Adler Planetarium's Teen Programs engage hundreds of young people in authentic STEM experiences each year. Adler's programs empower teens in the roles of active researchers and advocates. Several of our student programs focus on artificial light at night (ALAN), a critical issue for the environment, health, ecology, and astronomy.

The Adler's student program philosophy is rooted in active participation with new and important scientific research, engineering, and community engagement opportunities. Some of these projects include: The Aquarius Project (http://fieldnotes.staging.nationalgeographic.org/expedition/rovmeteoritehunt), a student-built underwater ROV designed to retrieve meteorites from under Lake Michigan; an instrument to capture stratospheric Earth spectra to help characterize potential biomarkers in exoplanet atmospheres; and a mission to image the 2017 solar eclipse from the stratosphere in 360-degree video.

For the past few years, we have used ALAN content in a variety of high school and undergraduate programs (AstroScience Workshop, Stratonauts, Y.O.L.O., High School Summer Internships, and ISGC Undergraduate Internships).

Here, we detail several cases of using ALAN content in high school programs. We highlight one program in particular - the High School Summer Internship - to explore in detail the challenges and adaptations made in remote programming due to this year's COVID-19 restrictions.

ALAN RESEARCH CONTENT

In 2016, Adler astronomers, engineers, volunteers, and undergraduate interns in the Far Horizons program began developing NITELite, a mission to map light pollution from high-altitude balloons. Interns served as both researchers - solving technical problems and building flight systems - as well as mentors to high school program participants. Along with NITELite, a system of ground-based light pollution observing cameras were designed to support the remote sensing mission. The Ground Observation Network (GONet) cameras offer an instrumentation advancement for ALAN research.

NITELite

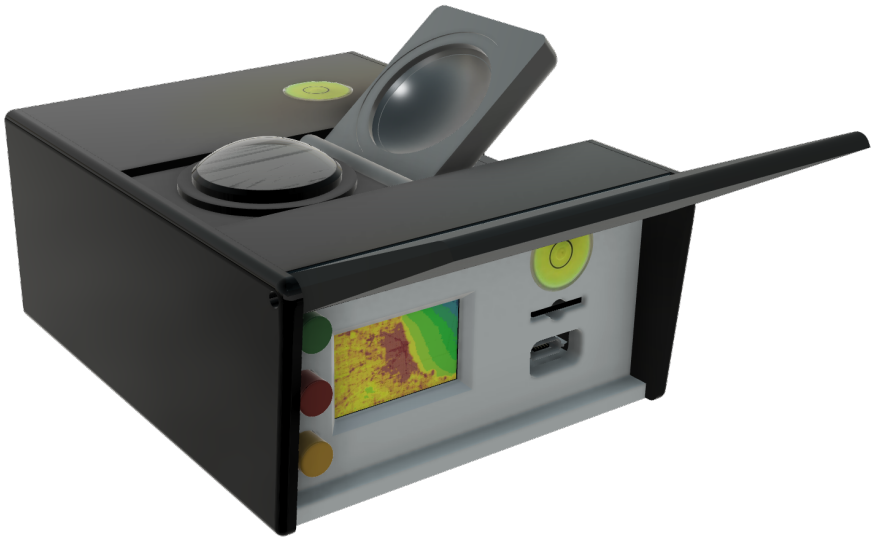
Night Imaging of Terrestrial Environments Lite (NITELite)

With an experience of over 13 years and 130 high-altitude balloon (HAB) flights used for student programs, we focused efforts on the design of an imaging instrument to map light pollution from the stratosphere. Using a HAB platform for remote sensing of ALAN had not been done before.

GONet Cameras

The GONet (Ground Observation Network) camera is an inexpensive (~USD 100), simple to use, all-sky imaging system designed to take ground-based measurements of sky quality at night. Due to their ease of use and low price, GONet cameras allow observations by users with little technical expertise, large inter-comparison campaigns, and deployments of

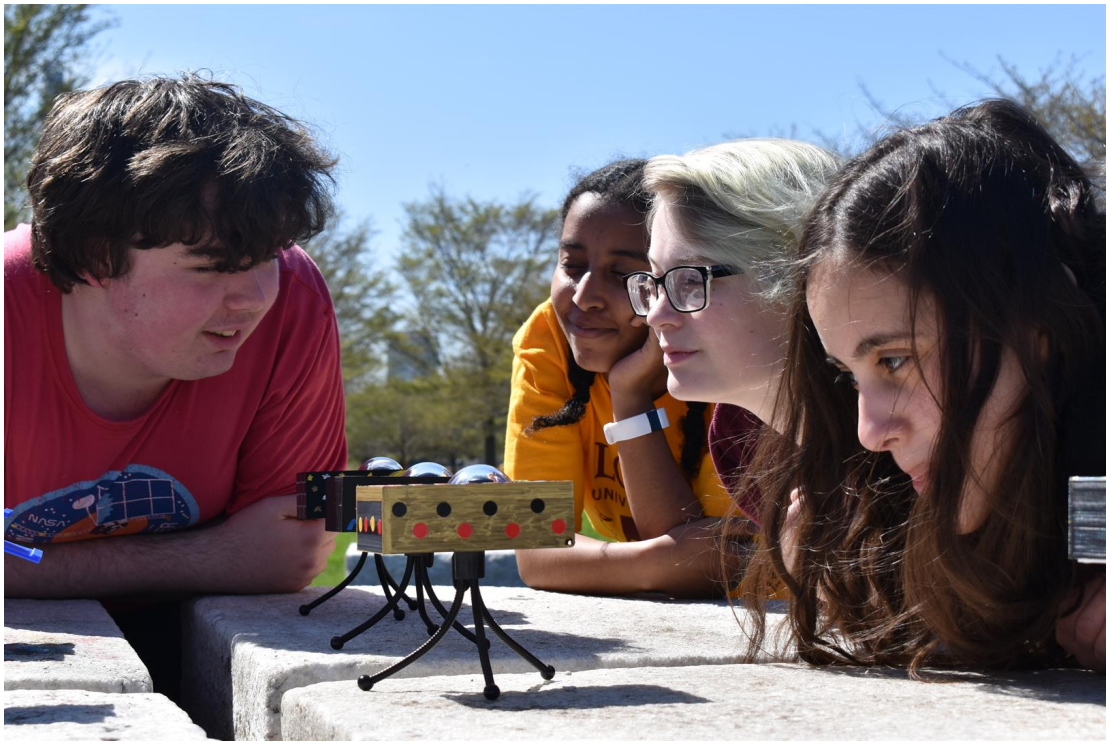
opportunity. It was developed as a student engineering project at the Adler Planetarium.



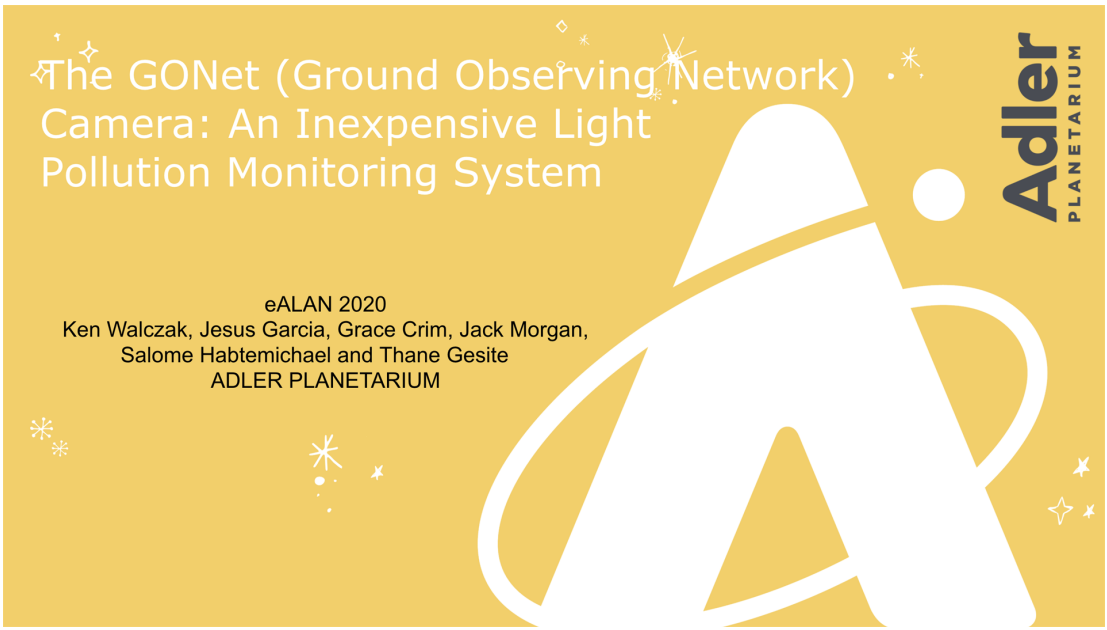
STRATONAUTS

Hands-on Science Teen Cohort Program

In 2019, teens in the Stratonaut program - a high school, school-year cohort of 16 students - helped design, build, and test the first GONet camera systems.



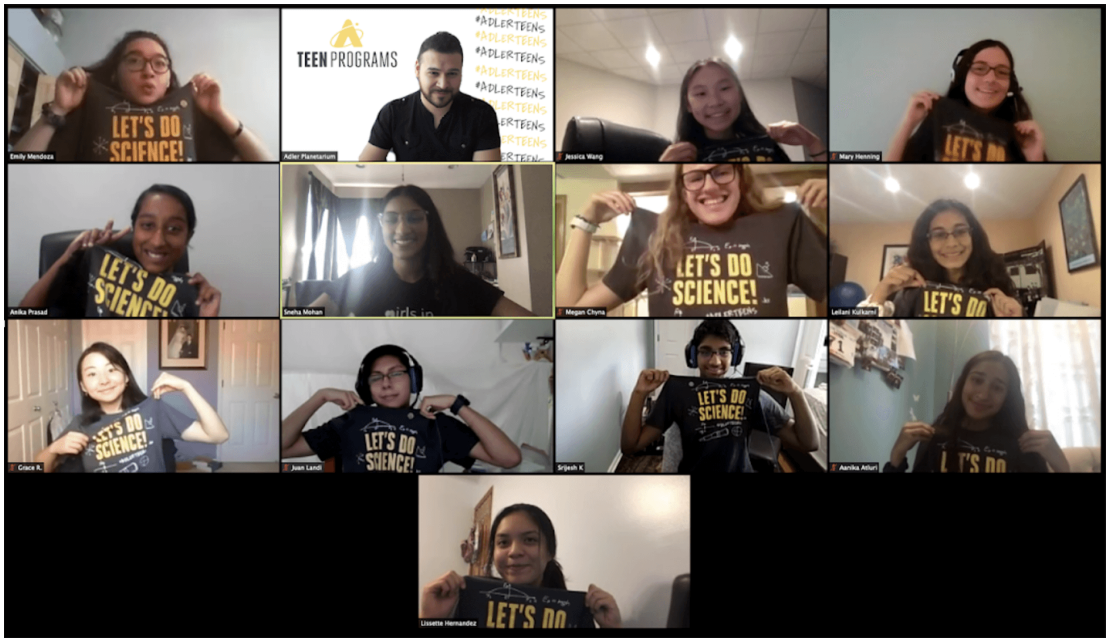
Four of the teens were able to present their work at the 2020 International Artificial Light At Night conference. The conference was originally to be held in Spain, but moved online due to COVID. This allowed an opportunity to attend and present at the conference that the students would not have had otherwise.



Due to the impact of COVID, initial plans to have a Fall 2020 cohort of the Stratonaut program were canceled. Plans are now to continue the program remotely in the spring of 2021, applying lessons learned from our 2020 program experiences.

ASTRO SCIENCE WORKSHOP

HS Research and Engineering Program



Since 1964, the Adler Planetarium has hosted a program for highly motivated and interested high-school students known as the Astro-Science Workshop (ASW). ASW began during the space race and the Apollo program, and counts numerous scientists, engineers, business leaders, and even a former NASA astronaut as alumni. ASW is a summer program featuring hands-on, student-driven investigation and experimentation working with astronomers, engineers, and educators at the Adler Planetarium.

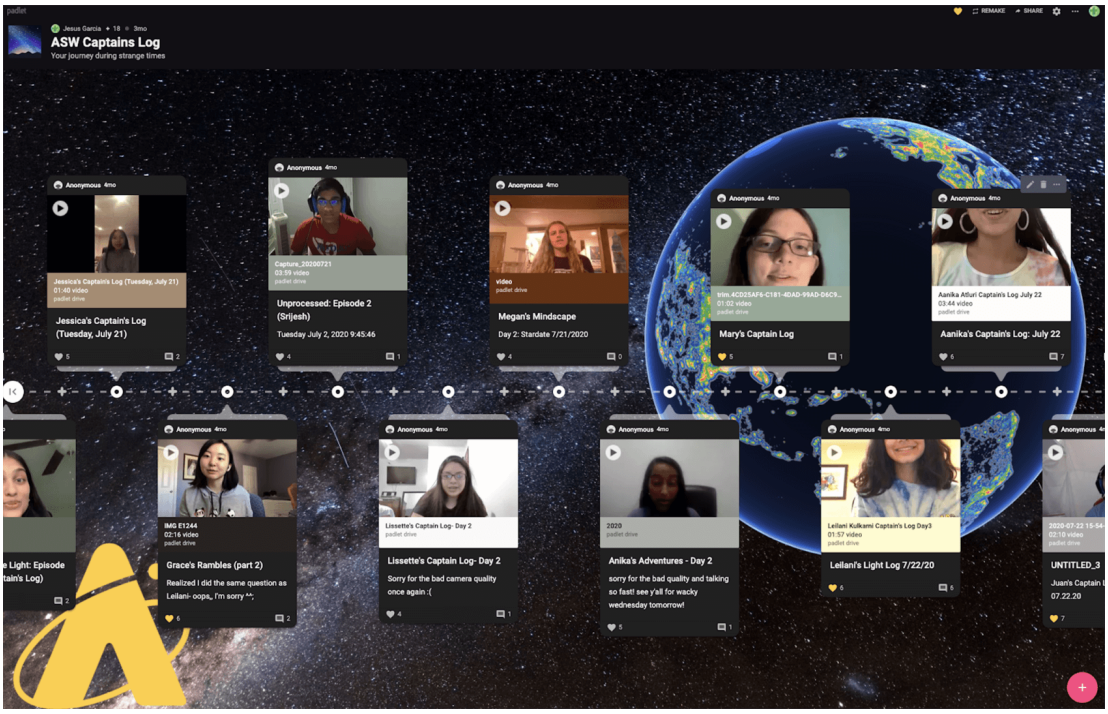
In 2020, there were 12 ASW participants. Their projects focused on ALAN as it relates to ethical design with built and natural environments. In their role as engineers, they researched light pollution effects on the environment, health, and the conservation of the night sky. With this research, they set out to design smart lighting solution models that take into consideration the environmental impacts of artificial light.

Skills Building:

ASW students were introduced to technical skills via guided workshops and hands-on activities, including the

fundamentals of electronics, circuit design, CAD, engineering methodology, and research. Each was mailed a custom kit of materials to use throughout the program.

Relationship Building:



Throughout their process, participants gained confidence in their own technical ability related to electronics, coding, and mechanical design, while learning to become leaders, project organizers, and science communicators. Although we were physically separated by the stay-home order, participants took full advantage of the opportunity to bond, laugh, and become friends through the many team builders and our “Captain’s Log” activities - an activity in which participants recorded their reflections about their day and commented on their peers' videos.

Results:

With only three weeks to complete this project (at their own homes), participants created a fully functional diorama or model of an environment containing their Smart-Lighting Solution. Upon completion of their physical model, participants used the online platform, Instructables, to publish an open-source How-To for their project, where others can view and access all design files and instructions to create their very own Smart-Lighting Solution.

Program goals are summarized by:

Skills & Knowledge Enhancement:

- Light Pollution Awareness
- Technical Confidence in electronics, computer science, and mechanical design
- Leadership, Engagement, and Personal Growth
- Science Communication
- Organizational Skills

Relationships Building:

- Fun Team Builders
- Captain's Log Videos - Document Progress, Growth, and Achievements (via Timeline on Padlet)

Outcomes:

- Developed Smart-Lighting Solution Models to ethically address light pollution in and around our environment
- Shared Light Pollution Overall Process, and Technical Documentation (via open-source educational platform, Instructables)

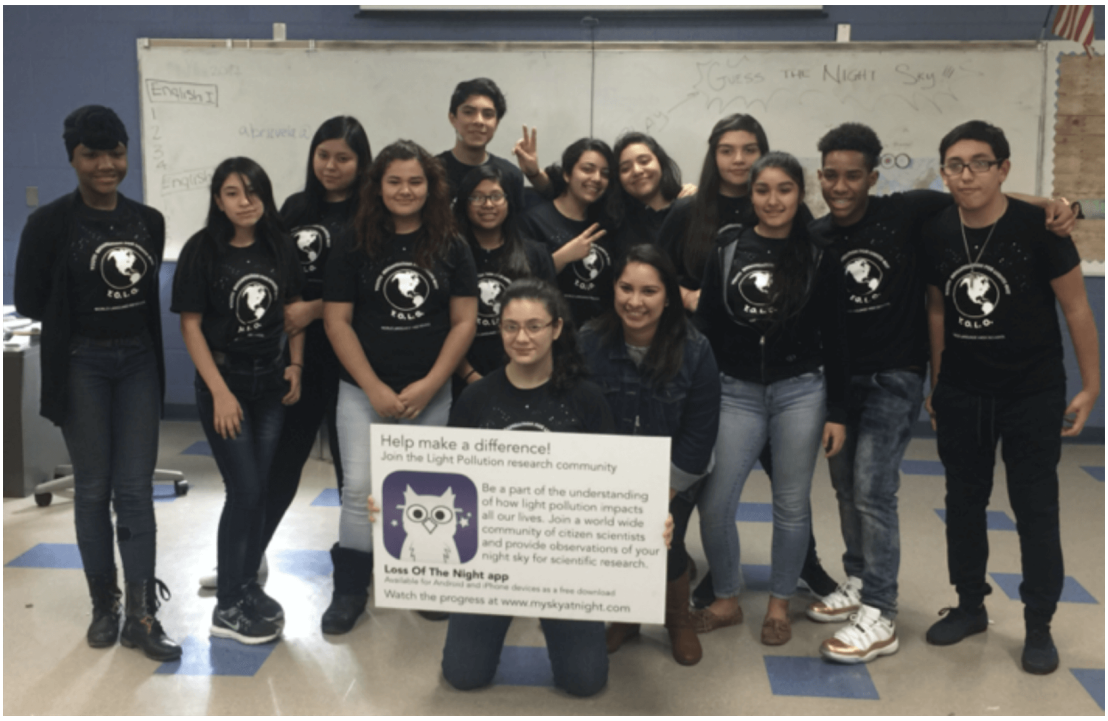
Public Share-Out:

- Participants created four Smart-Lighting Solution Models containing
- Light Pollution Solutions Videos
- Schematic Diagrams
- Microcontroller Code
- Flow Charts
- Documentation available via Instructables

Y.O.L.O.

Youth Organization for Lights Out:

After School Teen Engagement Program



Y.O.L.O. is a bilingual program in English and Spanish based in Chicago's predominantly Mexican and Mexican-American Little Village neighborhood.

In 2015, YOLO was our first teen group to do ALAN work through community advocacy and education. By researching the night sky from Chicago's Black and Brown neighborhoods, and National Park sites, Y.O.L.O members create opportunities to educate and raise awareness about the need for municipal change. YOLO started at World Language High School. Due to COVID and remote learning, the program has been expanded to students throughout the city of Chicago and surrounding suburbs.

YOLO program teens use tools to collect and analyze light pollution data, attend field trips to local and state dark sky sites, facilitate telescope viewing at the Adler and in their community, and develop prototype solutions and action plans to increase awareness of light pollution's local effects in Chicago.

Learning how to use the Loss of the Night app and sky quality meters (SQMs), students compare data collected in their backyard to a national park site.

Many teens have not experienced a dark sky, have not left their neighborhood, or the state. We have had teens cry in seeing so many stars for the first time.

Above: Teens using an SQM at Indiana Dunes National Park, an hour away from Chicago

Above: Photograph of a starry sky taken by a teen at Middle Fork Forest Preserve, an IDA Dark Sky Park in Central Illinois, 2.5 hours away from Chicago.

The Principles of Environmental Justice:

As YOLO focuses on advocacy and educating others about light pollution, we start by understanding that light pollution is not just an astronomical issue but an environmental issue. Focusing on black and brown neighborhoods, we build an

understanding of the Principles of Environmental Justice (https://www.nrdc.org/sites/default/files/ej-principles.pdf). These are the 3 that align with YOLO's mission.

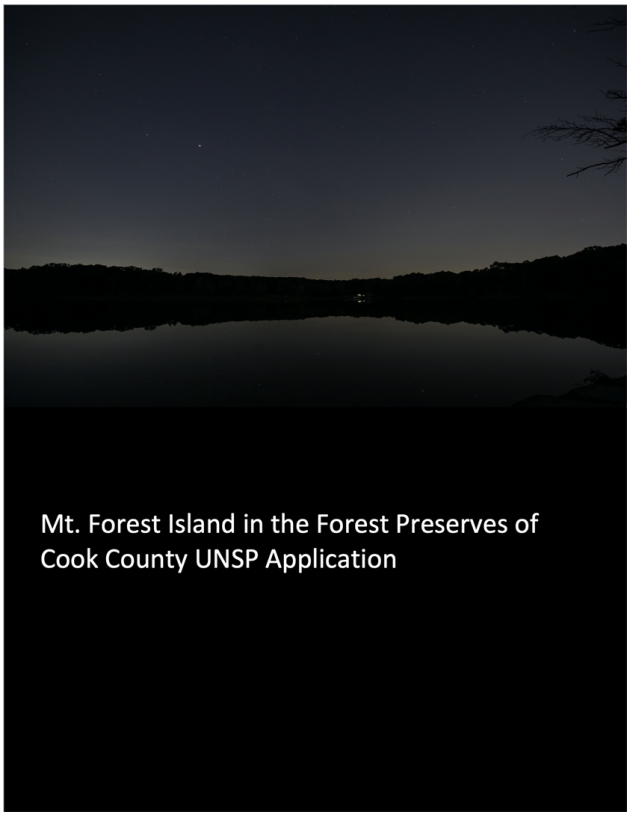
5) Environmental Justice affirms the fundamental right to political, economic, cultural, and environmental self-determination of all peoples.

12) Environmental Justice affirms the need for urban and rural ecological policies to clean up and rebuild our cities and rural areas in balance with nature, honoring the cultural integrity of all our communities, and providing fair access for all to the full range of resources.

16) Environmental Justice calls for the education of present and future generations that emphasizes social and environmental issues, based on our experience and an appreciation of our diverse cultural perspectives.

ANATOMY OF A REMOTE 2020 STUDENT PROGRAM: HS INTERNS AND URBAN NIGHT SKY PLACE DESIGNATION

The Adler HS Summer Internships are an annual 6-week, paid, full-time summer internship for high school students. They are typically structured as an in-person, hands-on program at the Adler Planetarium. The internship content is designed as part professional development, part peer-to-peer community building, and part project-based programming working with professionals at the Adler.



For the 2020 Far Horizons portion of the Adler Planetarium Summer Internship program, four high school students worked with Adler staff and volunteers with a goal of collecting night sky quality data and creating a report in support of an application for an international Urban Night Sky Place (UNSP) designation of a 6,600-acre area of the Forest Preserves of Cook County (FPCC) referred to as Mt. Forest Island.

The program design created to be successful in this goal required a number of steps:

- Content knowledge about ALAN
- Understanding of UNSP designation
- Learn data collection and science methodology
- Coordinate and perform quality observations
- Learn data analysis methods
- Create a report and presentation
- Perform presentations to stakeholders

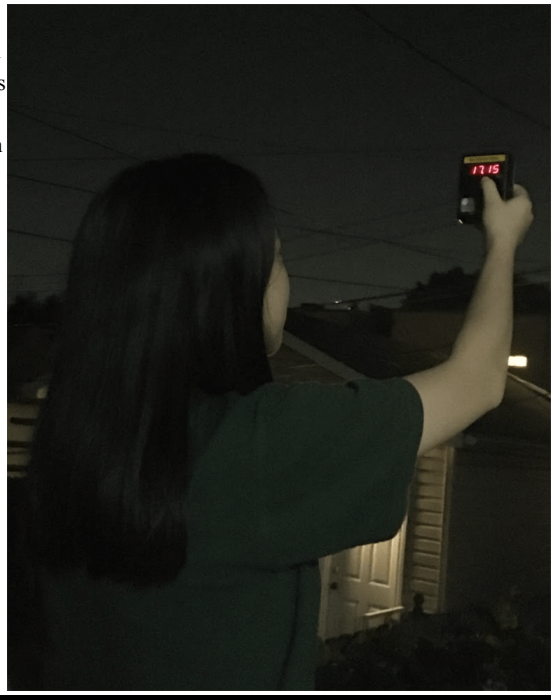
Hands-On Activities:

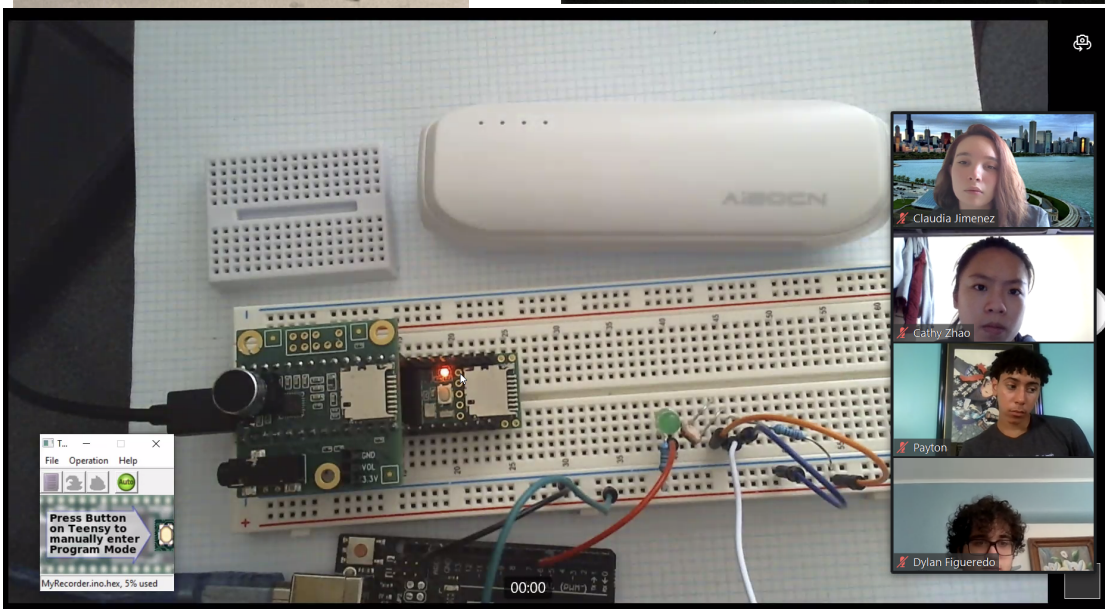
The interns were sent a kit at the beginning of their internship with a GONet camera, a Sky Quality Meter (SQM), and the electronic components for a project to build a remote sound logging instrument, using a Teensy board, to use in tandem with the GONet cameras.

After training, they tested their use of these instruments from their homes at night. With frequent feedback and practice, they became proficient at using the GONet cameras (left) and SQMs (right).

The sound logging project, which was more learning-intensive and skills-dependent, had a less successful outcome, although the interns expressed they enjoyed the technical skills experience they received regardless of the ultimate outcome of the device. In retrospect, Far Horizons staff who facilitated the program have speculated that perhaps, given the challenging circumstances due to the COVID pandemic, it may have been better to keep things simpler and confine all

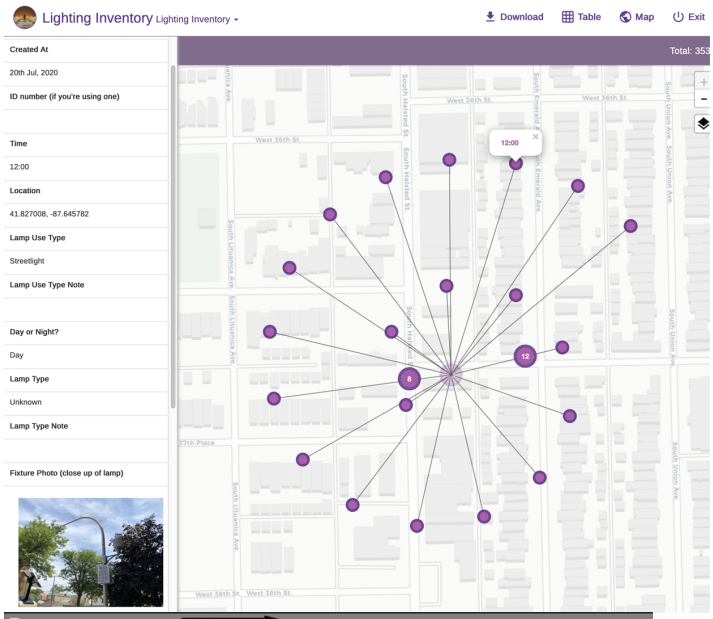
of the program activities fully to the main goal of

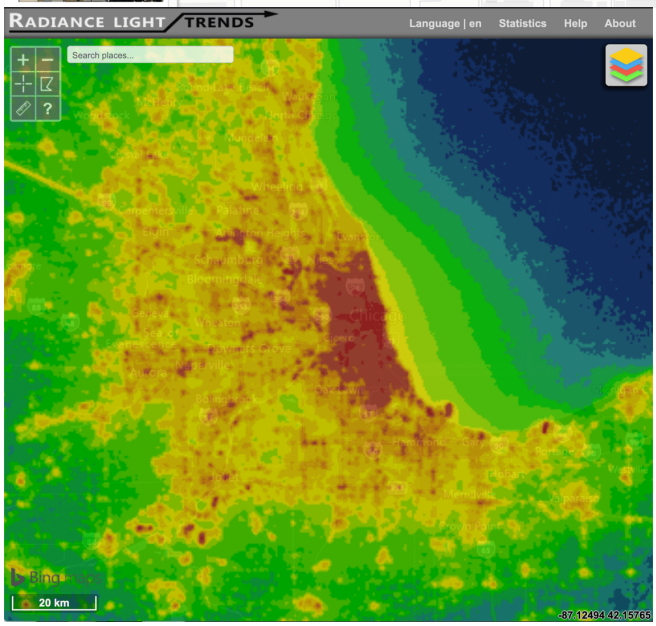




supporting the UNSP application, which focuses solely on night sky quality and does not involve a sound component.

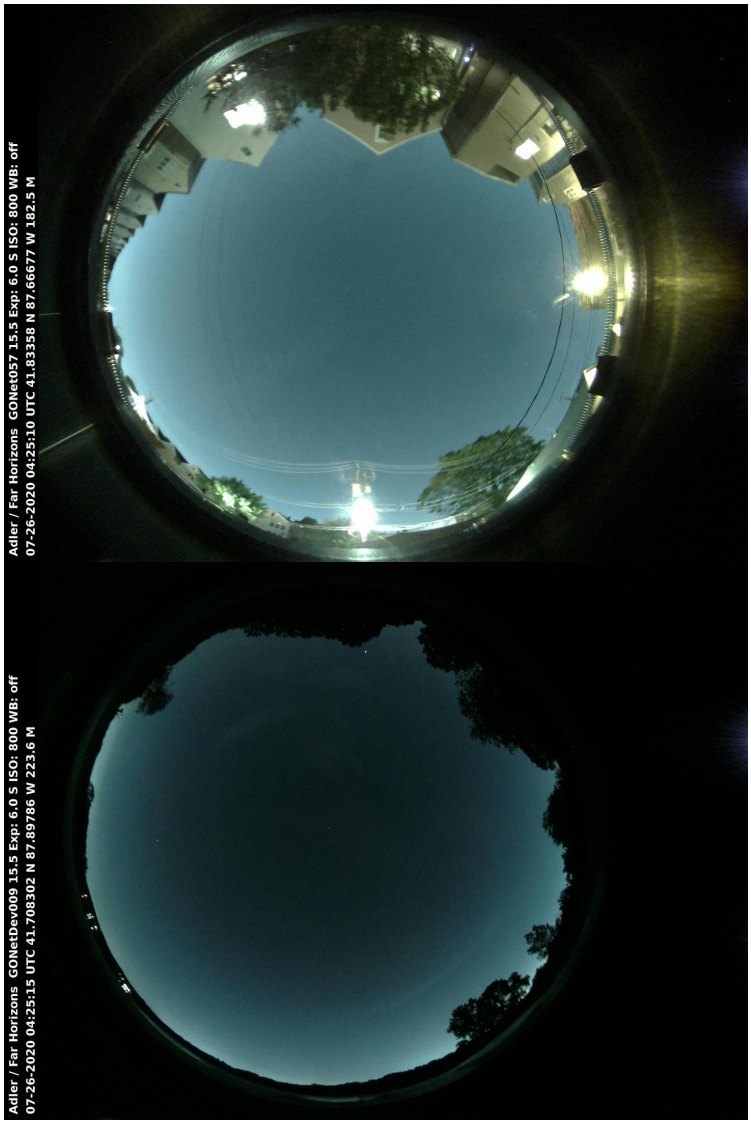
Online Activities:





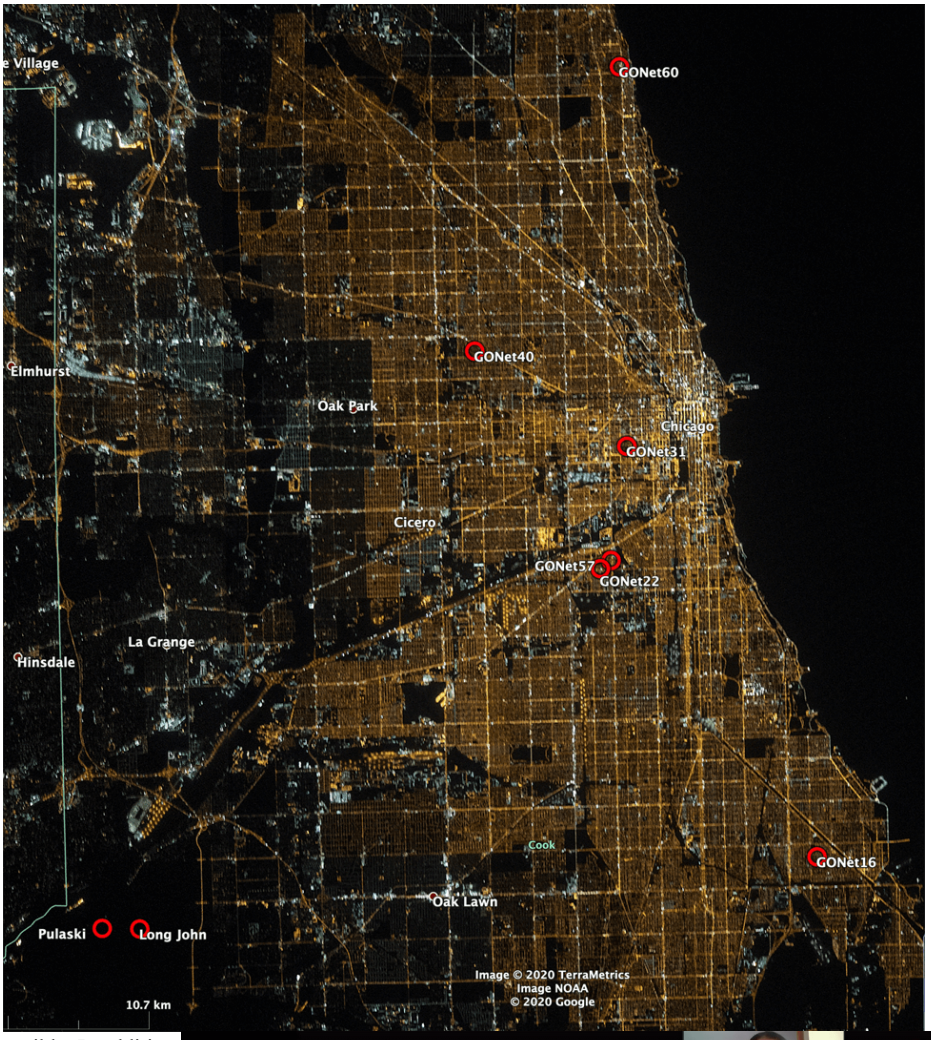
Using online tools, we designed activities to introduce and engage the interns in the subject of light pollution. The focus was always on creating a personal connection to the experience and the data. **Above right**: Using the citizen science inventory project builder, Epicollect5 (https://five.epicollect.net/), we tasked the interns to create an inventory of lighting in their neighborhoods. It helped build an awareness of the number of lights in their environment as well as revealing the difference between different students' neighborhoods. **Above left**: We used the website Radiance Light Trends (https://lighttrends.lightpollutionmap.info) to design an activity to compare light pollution in their own area to other locations around the world. The site allows one to select an area and see the quantity and trend of light emissions over time. After choosing their own neighborhood for training, each intern was tasked to explore any place of interest in the world to compare. Some chose places they had visited. Others chose places from where their families originated. The personal connection helped to strengthen the interest in the data.

At Home Observations:



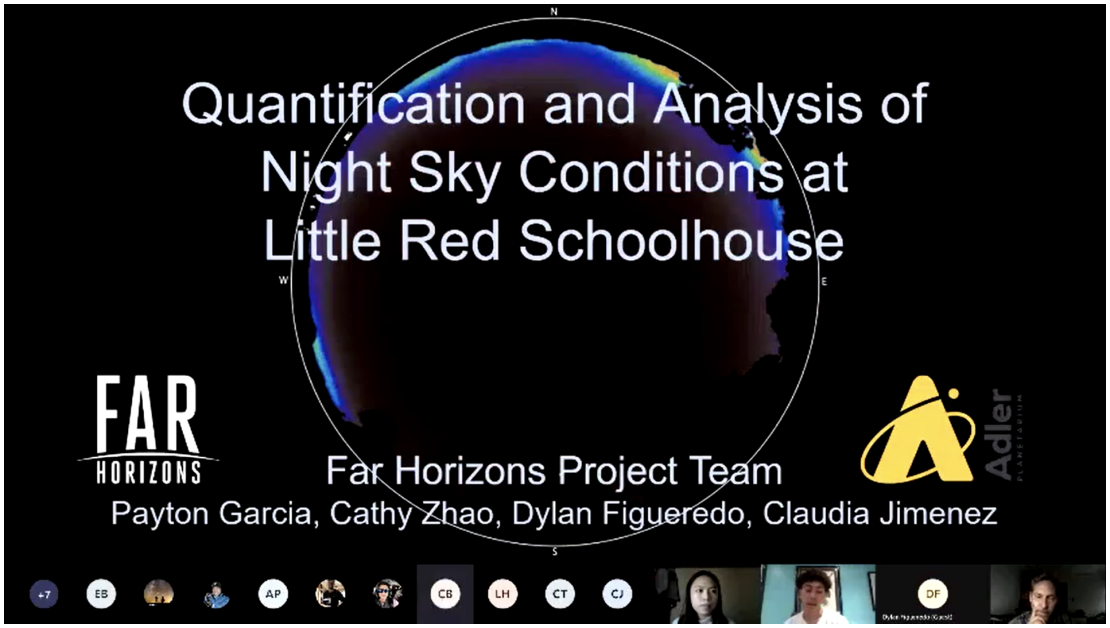
Due to COVID restrictions, the original intention of gathering in-person to perform observations together at Mt. Forest Island had to be canceled. Instead, interns, staff, and volunteers participated in coordinated observations from their homes, while one program staff member simultaneously performed observations at some sites within the Mt. Forest Island area. This alternate approach ended up being a benefit to the project. The interns were able to use the observations from each person's home to create a regional intercomparison that helped to put the quality of the night sky at Mt. Forest Island in better context. Additionally, since the interns did observations from their own homes, they were each able to compare their own personal environment to the destination area (See: above)

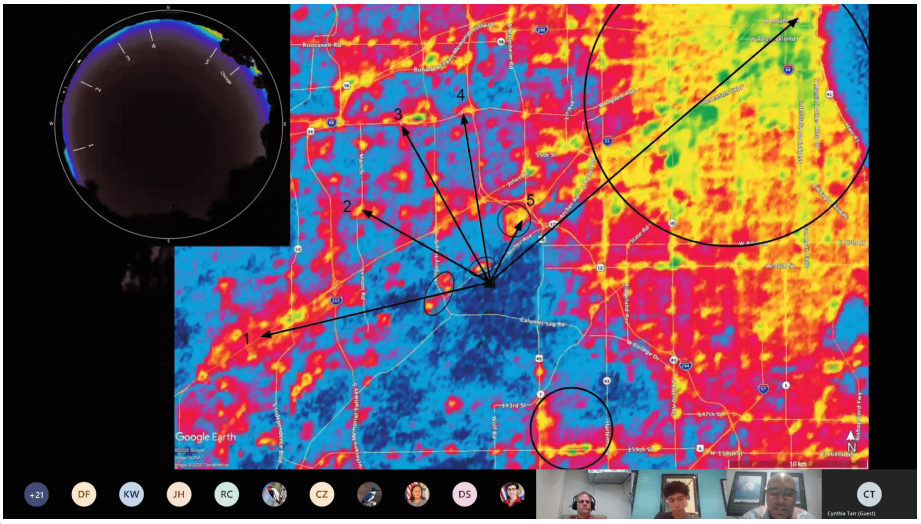
Also, the geographic distribution of the interns, staff, and volunteers who participated helped to reveal variations in the conditions even within the city of Chicago. This inspired discussion and questions about the different nighttime lighting environments across the city and region.



Professional Talks and Presentations:

COVID restrictions ended up helping us arrange professional speakers for our program. We were able to host speakers from NASA, the NPS (right), and local researchers. All our speakers were to some degree also adapting to the physical restrictions from COVID. This created availability for at least one of our invited speakers, which would otherwise not have been possible. In addition, communication with the NPS over the course of making arrangements for their guest speaker highlighted to them our focus on remote programming, which prompted the NPS to extend an invitation for our interns to present their work during one of the NPS virtual meetings.





The interns presented their results to the National Park Service's Natural Sounds and Night Skies Division (above) and the Forest Preserves of Cook County (right), as well as to fellow interns and their families.

Having the opportunity to present their work to a number of audiences with a wide range of background knowledge helped the interns strengthen their science communication skills. Ironically, their first presentation was to the NPS group, who are research professionals in the field of ALAN. By the time they presented to their peers and families their confidence and presentation skills were noticeably stronger.

CONCLUSIONS

Tailoring programs originally intended to be in-person was challenging, yet it afforded some tangible benefits.

Challenges of online programming:

- Integrating a hands-on aspect is difficult and more costly
- Providing 1-on-1 support for technical challenges is less efficient and often complicated
- Fulfilling the need to reduce screen time can be difficult while still maintaining program goals

Advantages of online experience:

- Broader access to speakers due to the online format
- Greater focus on interns' observations and awareness in their own environment
- More opportunities to present at conferences and organizations due to the relative ease and low expense of presenting virtually

A key lesson we learned was that flexibility was crucial to program success when operating remotely. Flexibility in goals as well as methods helped us work through program redesign. The experience helped to give our Teen Programs team a crash course in virtual learning and engagement that we can apply to future programming. In fact, we have already begun to apply and refine lessons learned for our fall programming.

ABSTRACT

The Adler Planetarium's Teen Programs engages hundreds of young people in authentic STEM experiences each year. Several of our programs focus on artificial light at night (ALAN), a critical environmental, health, ecological and astronomical issue. Our work in ALAN Community Advocacy and Education began in 2015 through Youth Organization for Lights Out (YOLO), a bilingual program in English and Spanish based in Chicago's predominantly Mexican and Mexican-American Little Village neighborhood. YOLO program participants use tools to collect and analyze light pollution data, attend field trips to local and state dark sky sites, facilitate telescope viewing at the Adler and in their community, and develop prototype solutions and action plans to increase awareness of light pollution's local effects in Chicago. Programs focused on Instrumentation and Research grew out of the Adler's educational high-altitude ballooning program, Far Horizons. In 2018, Far Horizons astronomers and engineers began developing Mission NITELite (Night Imaging of Terrestrial Environments), a high altitude balloon-based light pollution mapping mission along with undergraduate interns. To complement NITELite, Far Horizons designed GONet (Ground Observing Network), a low-cost all-sky imaging system to measure sky quality at night as part of its Stratonauts teen program. In 2019, high school students helped design, test, and build 50 GONet units as a potential new standard for worldwide ALAN monitoring. In 2020, Adler teen interns are working with the Cook County Forest Preserves to quantify regional sky quality with GONets in support of an application for an Urban Night Sky Place designation from the International Dark-Sky Association. Reflecting the collaborative nature of science, teens in the Instrumentation and Research programs partner closely with peers in the Community Advocacy and Education programs, learning from one another's perspective while undertaking joint projects.

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