Learning in a Pandemic: A Model for Virtual Outreach

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ABSTRACT

When the Covid19 pandemic closed schools including K-12 and colleges, hands-on science labs and outreach events were also canceled. The question was how to continue to engage students and adults of all ages in optics outreach while they were at home and school lab equipment was not available. Our solution was to provide optics at-home workshops that teachers and students could do with their families using readily available items. The authors with the assistance Optica (formerly The Optical Society, OSA) developed and presented a series of eight outreach workshops through the *We Are On* program.
Keywords: Virtual outreach, Hands-on learning, Optics education, Dumpster Optics, Optics Magic, low-cost education, STEM education

1. BACKGROUND: EVOLVING FORMATS FOR IN-PERSON OUTREACH

In the early 2000s, in partnership with the Three Rivers Community College's Optica (formerly OSA) and SPIE student chapters (Norwich, CT), authors Donnelly and Magnani began collaborating on optics/photonics outreach and presenting workshops to primary and secondary school students throughout eastern Connecticut (USA) [1]. Some of the workshop demonstrations were inspired by participants in the National Science Foundation supported PHOTON projects who brought their favorite demonstrations to share at PHOTON events. Others were influenced by the creative presenters at Educators' Days held in conjunction with Optica's Frontiers in Optics (FiO). In 2010 they began offering yearly hands-on outreach workshops at SPIE's Optics and Photonics meeting (O&P), engaging participants from industry and academia as well as local educators who were interested in science outreach. The workshops were also offered at several ETOP (Education and Training in Optics and Photonics) conferences, including a large workshop for 40 school children at ETOP 2019 in Hangzhou, China. Workshops and outreach events alike featured low-cost optics "takeaways" that participants could bring home to show their friends and families.

Initially the workshops were called "Optics Magic" or "Optics Outreach Magic" and included simple but eye-catching optical phenomena based on the sixteen Optics Explorations of the PHOTON Projects [2]. By 2014 the focus had shifted from quick demonstrations to more in-depth lessons aligned with U. S. national science standards (Next Generation Science Standards, *NGSS)* suitable for 10-12-year-old children. Each of the inquiry-based lessons asks students to make hypotheses, perform experiments and describe their conclusions. The lessons were presented in classrooms and at Laser Camp student conferences throughout Connecticut. Teachers were provided with in-depth notes and lesson plans so they could follow up with students and teach the lessons themselves in future years.

In 2014, the set of lessons was renamed "Dumpster Optics" (by Kathleen Robinson, then Manager of Education Services at SPIE) in recognition of the materials used – simple, inexpensive, easy to find, and in some cases, items headed otherwise for trash or recycling. In the following years, variations of the Dumpster Optics workshop were presented in many venues including school classrooms and at O&P and ETOP conferences [3]. The easily available materials used in the lessons allowed students to try them at home and made them accessible as outreach presentations for organizations without large budgets for supplies or access to lab materials. The nine Dumpster Optics lessons are currently hosted on the PBL (Problem-Based Learning) Projects web site (www.pblprojects.org/dumpster-optics) at no cost for users. Each lesson consists of PowerPoint slides with instructions for students (in English and in Spanish), a document with detailed instructions for teachers or parents (including what can go wrong and how to fix it), and pages for students to record data and observations. Figures 1 and 2 are screen shots from the PBL Projects web site showing the typical structure of a Dumpster Optics lesson.

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Figure 1. Typical Dumpster Optics supply list; teacher/parent notes have more detail on where to find or buy supplies, typically for under $2-3 US for items that might need to be purchased.

POLARIZED LIGHT ART

ARTE DE LUZ POLARIZADA

WHAT IS POLARIZED LIGHT? HOW DO POLARIZED SUNGLASSES WORK? CAN YOU USE POLARIZED LIGHT TO MAKE COLORFUL ART OUT OF TRANSPARENT MATERIAL?

This STEAM lesson has includes both science and art activities.

MATERIALS:

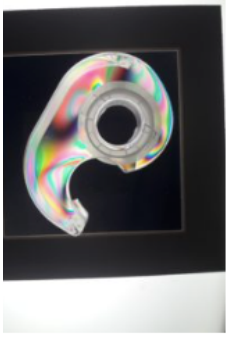
Activity 1: A polarizing filter (polarizer). This can be the lens of polarized sunglasses or a piece of polarizing film (available from science supply houses), and an LCD screen such as a laptop monitor or television screen.

Activity 2: Polarizer and a bowl of water

Activity 3: Two polarizers

Activity 4: Polarizer and a piece of cellophane tape (like Scotch® tape) or food wrapper. Cellophane is the thin transparent film often used for food packaging or wrapping gift baskets. Some types of clear plastic will also work for this experiment – try them first.

Figure 2. Documents available for downloading include PowerPoint slides in English and in Spanish. Links to relevant videos produced by the PHOTON projects are also included.



STUDENT INSTRUCTIONS AND TEACHER NOTES

PowerPoint slides with student instructions Polarized_Light_Art_Slides.pptx

Presentaciones de PowerPoint con instruacciones para estudiantes Arte polarizado.pptx

Teacher notes Polarized_Light_Art_Teacher_Notes

Student Observations Polarized Light Art Observations

VIDEO: Exploring Polarization

VIDEO: The Magic Box (An illusion using polarized light)

VIDEO: Polarized Light Art

2. TRANSITION TO VIRTUAL OUTREACH 2020

The idea for a virtual (online) series of hands-on workshops arose during a video meeting on a related but different topic, a request in March 2020 from Optica to develop a simple video illustrating for children the confinement of light in a water jet. The conversation led to a comment that in-person outreach workshops had essentially stopped due to the pandemic. In addition, schools were closed and students of all ages were at home with little access to science content. The idea of a series of virtual online workshops was discussed and a plan was made to develop and present them. The workshops would need to be family/parent friendly because the participants would not have access to a traditional science teacher. Four webinars/workshops were planned, one for each Friday in May 2020. These proved so successful that a second series of four workshops was offered in Fall 2020 as many students continued to be at home with on-line learning. The audience was international and included participants of all ages. (Figure 3 and Table 1) Participation was higher in the spring session, probably because by the fall some schools were back in session in an online or hybrid format.

Figure 3. (Left) Some webinar participants with spectroscopes they made of cardboard tubes, aluminum foil, and stripped pieces of CDs and (Right) what they were looking at

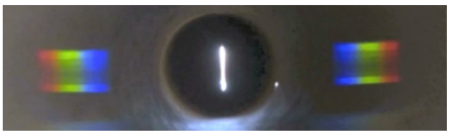


Table 1. Number of participants and countries represented for the eight online workshops.

Date	Title	No. of Participants	No. of Countries
May 8	The Colors of Light	55	18
May 15	Light and Shadows	47	11
May 22	Reflecting on Light	73	22
May 29	Twisting Light	55	18
Oct. 16	Things That Glow	28	8
Oct. 23	Lasers and Flashlights	16	4
Oct. 20	What Can You Do With a Laser	33	8
Nov. 6	What Else Can You Do With a Laser	19	5

3. ADAPTATIONS FOR ONLINE WORKSHOPS

Of course, several accommodations had to be made for an online workshop format including the supplies that participants would use, our presentation method and technical issues related to broadcasting live science.

3.1 Supplies for online outreach

For on-site workshops we provide participants with a plastic supply bag containing items ranging from LED finger lights to cardboard mailing tubes. In the stay-at-home format, participants' travel and shopping were restricted, so they would have to provide their own supplies from around the house wherever possible. Optica's announcement of the workshop included a list of easy-to-find household materials for participants who wanted to try the experiments at home. The goal was to use as many as possible commonly available materials that participants likely had at home. As is the case with all Dumpster Optics activities, no required item costs more than one or two US dollars. Wherever possible, we use recycled items like old recordable CDs, aluminum foil, cardboard boxes, and mailing tubes. The only purchased items might be the laser pointer, LED finger lights or keychain lights, and UV flashlights, items that could be purchased even during the pandemic from online sellers like Amazon.com or dollar stores. The workshops were truly in the spirit of Dumpster Optics.

3.2 Live presentation format

The presenters also adapted the presentation format for on-line learning. Hosting by Optica was critical to the success of the webinars; the presenters were freed from the complexity of handling technical issues while also

presenting the material. Optica marketed the webinars as part of its *We Are On* program, including marketing to AAPT (American Association of Physics Teachers) as well as Optica members. The society also registered participants and sent reminders and log-in information. All of the webinars were recorded so they remain accessible to those who were unable to attend. [4] Webinar topics are shown in Table 2.

Table 2. Topics addressed by the eight hands-on webinars

Date	Title	Topics
May 8	The Colors of Light	Make a CD spectroscope and look at light spectra from various sources.
May 15	Light and Shadows	All about light rays. How does a pinhole camera work?
May 22	Reflecting on Light	What reflects light? What is the law of reflection?
May 29	Twisting Light	Use polarized light to create art from sticky tape.
Oct. 16	Things That Glow	What are phosphorescence and fluorescence? How are they alike/different
Oct. 23	Lasers and Flashlights	Compare laser light to light from a flashlight.
Oct. 20	What Can You Do With a Laser	Measure hair diameter by diffraction. Only minimal mathematics required!
Nov. 6	What Else Can You Do With a Laser	See your pulse, gelatin optics, and light painting.

Other considerations included lighting to effectively demonstrate the activities, presenting in a home office, how to engage participants that we could not see, and dealing with time zones. Not only were the participants located around the world, but the presenters and Optica hosts were also in three geographically diverse locations and time zones. We used three web cameras and 3 laptops to present the workshop, including one set-up dedicated to sharing the PowerPoint slides and one for live recording of the hands-on experiments. This allowed us to shift focus without having to stop and screen share, and we were able to do the experiments in real-time. (Figure 4, Left) Unlike our more extemporaneous in-person workshops, the webinars required two or three practice sessions and planning meetings beforehand. Before going "live", we practiced with young participants (grandchildren, assisted at times by their mother) to make sure our instructions were clear and easy to follow. (Figure 4, Right). Although our practice sessions participants were younger than the expected webinar participants, we knew that if they could follow our directions the adult participants should have few problems.

Figure 4. (Left) Set up for live demonstration and PowerPoint slides (Right) Practicing video presentation of the instructions before a webinar with (grand)children ages 5 and 8.

Webinar participants were able to interact with the hosts through chat and Q and A features, and questions and comments were welcomed and encouraged. Using the chat feature did take some practice for participants. We would open each session asking the participants to tell us where they were located. This gave them the opportunity to use the

chat and we could interact with them before the lesson started. It also gave late arrivals a chance to enter the session. Answers to questions we did not have time to answer live were posted on the PBL Projects website, www.pblprojects.org/resources-from-pbl-osa-webinars/. Our Optica host remained online but in the background throughout each webinar to handle any technical issues so we could concentrate on content.

To encourage participants to sign up for more sessions, we had a couple of "contests" for them to share their work. At two of the webinars participants were invited to send photos of their own results, a spectrum as viewed in the cardboard tube spectroscope after "Colors of Light" or their own polarized light art from the polarization webinar. A small prize was given to the best entries by Optica.

Knowing that parents and families would not have the depth of knowledge to try these lessons and answer questions at home, the teacher documents for each lesson were reviewed and revised. We modified the Dumpster Optics teacher notes into a parent/teacher document for each webinar. Each downloadable document covers the science and technology of the lesson, provides hints for finding supplies and completing the experiments successfully, and resources for additional learning. In addition, the webinar slides were edited to be easily downloaded and used by participants. The guides and webinar slides are available on the PBL Projects website, along with a link to each webinar recording. With these resources, student chapters and home-schooling or public school teachers can easily continue optics outreach.

4. CONCLUSIONS

Through the *We Are On* webinar format, we were able to successfully reach a broad international audience, including homebound school students and their parents, university student chapter members, teachers, and industry professionals. This provided a rich dialogue among varying ages and backgrounds that we would not have with in-person workshops. Since many potential outreach participants (and their children!) cannot afford to travel to conferences, this format could provide an ongoing venue for presenting outreach, even post-pandemic.

The eight webinars will continue to be posted on the Optica and PBL Projects websites and we hope that student chapters and other groups restarting their optics outreach will continue to use these resources.

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