Reaching audiences big and small: Holistic approach to optics outreach at the Wyant College of Optical Sciences

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ABSTRACT

The Wyant College of Optical Sciences (OSC) at The University of Arizona participates in a variety of outreach activities in all levels of the education system and the Tucson community at-large, reaching thousands of students each year. We have created immersive workshops including "D.I.Y. Optics" and "CSI: Optics – Optical Forensics". For large audiences, we emphasize "pocket optics", cost-effective giveaways such as pixel magnifiers, the Pepper's ghost illusion, and Fresnel lenses. New resources and lesson plans are centralized on an online hub, which started as a UA/NASA Space Grant project in 2018 and now facilitates instructor training and acts as an on-demand resource for troubleshooting demos in the field. We share successes and lessons learned from our outreach events, culminating in an annual Laser Fun Day, the flagship student-led event supported by the Student Optics Chapter (SOCk) and Women in Optics (WiO).

Keywords: Outreach, optics, optical science, education, D.I.Y.

1. INTRODUCTION

Optical science has room to improve with name recognition as a field: for much of the public audience, "optics" only includes eyeglasses. By creating and sharing demonstrations that encompass a wide range of topics, the general public can catch a glimpse into ways that optics informs the development of cutting-edge technology.

At the Wyant College of Optical Sciences, students, faculty, and staff volunteer hundreds of hours every year participating in outreach events. During the 2017-2018 academic year, OSC volunteers reached over 6500 students of all ages across the Tucson community, and have met or exceeded that pace every year. Laser Fun Day is the flagship outreach event held annually on The University of Arizona campus, led by OSC student groups with support from faculty and staff. Each spring, the event draws hundreds to thousands of visitors to participate in hands-on optics demonstrations.

The outreach events led by OSC volunteers vary dramatically in size, from having several hours with a handful of students to the large community events with thousands of participants passing by. This means that there cannot be a "one-size-fits-all" approach to participating in outreach. This work addresses several key concerns to adapt outreach events to the size of the audience, freshen up some of the classic demonstrations, and improve the efficiency of outreach training and demonstration development.

We have created several themed workshops to engage with a small audience for several hours, as described in Section 2. For large scale outreach demonstrations, we have created several low-cost giveaways to be distributed which are outlined in Section 3. Lastly, the development of an online resource centralizes outreach information, facilitates training of new volunteers, and reduces duplicated work. This website is under continual improvement and will be growing as a free, publicly available resource for STEM classrooms, increasingly more important for the current times of social distancing due to COVID-19.

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2. IMMERSIVE THEMED WORKSHOPS FOR SMALL AUDIENCES

At the Wyant College of Optical Sciences, we are fortunate to have a large (and growing) list of demonstrations available for volunteers. A few popular demonstrations are in heavy rotation with volunteers, so it is possible they could lose their novelty for a particular audience. To avoid this and fully utilize the resources we have available, we grouped several demonstrations together to create new workshops focused on a central theme. These are ideal for a small classroom setting with about 30 students and can be customized to be between 1-3 hours. The following sections outline three of these workshops, D.I.Y. Optics, CSI: Optics, and Edible Optics.

2.1 D.I.Y Optics – Optical Instruments

The focus of "D.I.Y. Optics" is on creating optical instruments from household objects. Starting from historical techniques, we draw the connection to modern parallels, highlighting three primary crafts: pinhole camera, stereoscopes, and the Pepper's Ghost illusion. Figure 1 shows the crafts made from household objects for this workshop. A convenient form factor for a pinhole camera is a pringles can, where a pinhole is punched into the metal bottom and portion of the tube is cut to add a diffusing screen [1]. In our experimentation, Glad Press'n Seal was found to be the best diffusing surface when compared to wax paper or other plastic wrap, and it is self-adhering to the cardboard tube with no extra tape required. Similarly, Thorlabs Lab Snacks and Newport Photon Food boxes are convenient sizes for virtual reality viewers using the template from Google Cardboard [2]. In particular, these are most compatible with phones of a slightly smaller form factor, equivalent to the iPhone 5s. The third craft in this workshop is the Pepper's Ghost demonstration, which is also one of the "Pocket Optics" described in Section 4. We have a large Pepper's Ghost demonstration that uses a television as the projecting light source and can be viewed at a large distance, but a scaled-down version uses a phone and overhead projector transparency sheets. Each of these crafts has some time required for preparing materials, but the assembly, customization, and exploration is all done by the students.

Figure 1. Crafts featured in the D.I.Y. Optics workshop. Left: Pinhole camera using a pringles can; Center: VR Viewers; Right: Pepper's Ghost.

This workshop was tested during the University of Arizona Summer Engineering Academy (SEA), an event hosted by the University of Arizona College of Engineering for the past 30 years [3]. Our workshop was one of several during a week-long Women in Engineering camp held June 23 – 28, 2019. We hosted a 2-hour "D.I.Y. Optics" workshop for 14 attendees in the 9-12th grade range. In a post-event survey, all of our attendees rated our workshop as a 4 or 5, indicating "highly engaging and/or educational", illustrated as the top row in Figure 2.

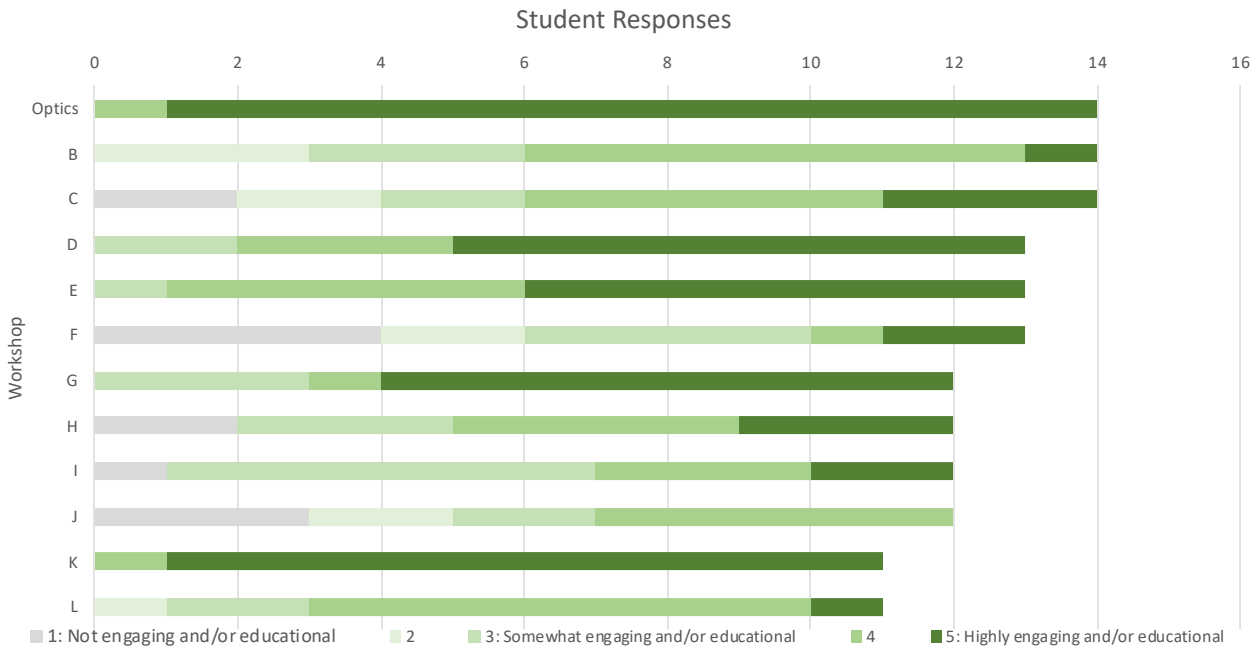

Figure 2. Student feedback in post-event surveys. As shown in the top row, all of the D.I.Y. Optics workshop attendees rated the workshop as a 4 or 5, indicating "highly engaging and/or educational".

2.2 CSI: Optics – Forensic Sciences

The second workshop we developed is inspired by the variations of crime scene investigation shows for our own version of CSI: Optics. We created several clues left as “evidence” at an imaginary crime scene and gave students the tools to be able to learn more by using optical techniques. By reaching out to the OSC community we gathered a collection of fibers, animal hairs, and various threads and tasked the students to determine the thickness of the strands by measuring the spacing of the diffraction pattern, analogous to the single-slit diffraction experiment. We also created footprints with UV paint, used a spectrometer to look at spectral analysis, and used a mid-IR camera to detect counterfeit money. To illustrate one of the potential failings of eyewitness testimony, we demonstrated how the color of shirts can be very difficult to identify when illuminated with high-pressure sodium lamps, like many of the streetlamps in Tucson. The comparison is shown in Figure 3.

Figure 3. Under a sodium lamp, all three shirts look like different shades of gray, but they are actually three different red shirts.

While portions of these demos had all been done in different forms in the past, we brought them together during the 2020 Optics and Photonics Winter School and Workshop, an event hosted by OSC for the past 5 years bringing undergraduates across the country to the campus for lectures, lab tours, and networking [4]. Our three-hour workshop had 15 attendees, and working in teams of three they were all very creative, coming up with different imaginary scenarios that may have led to the evidence we created as part of our imaginary mystery,

2.3 Edible Optics

The third workshop is a collection of food-based demos, which have individually been successful with audiences of all ages. The “electric pickle” transforms a pickle into a glowing light source, and other vegetables can have the same result when prepared with a salt solution [5]. A tray of Jello and laser pointers makes for an easy and highly interactive experiment on the effect of lens shape on the refraction of light. For integration with math activity, the speed of light can be calculated by heating a bar of chocolate in a microwave. Lastly, OSC volunteers have created molds to make candy lenses, shown in Figure 4.

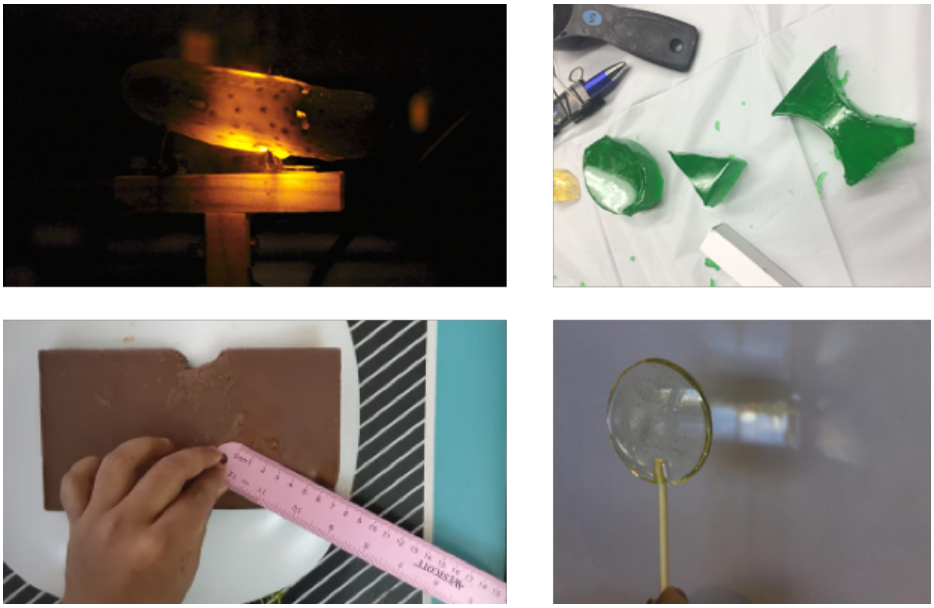

Figure 4. Food-based optics demos for the "Edible Optics" workshop. Top Left: Electric Pickle. Top Right: Jello Optics. Bottom Left: Speed of Light calculation by microwaving chocolate. Bottom right: Imaging with candy lenses.

3. “POCKET OPTICS” FOR LARGE AUDIENCES

The workshops outlined in Section 2 ideal for an immersive experience with a small audience, but impractical for large community events. OSC participates in several annual events that draw hundreds to thousands of participants such as the SARSEF Future Innovator’s Night, Tucson Festival of Books, and OSC’s Laser Fun Day. In contrast to the immersive workshop settings, instructors may be at a booth with a short window to grab the attention of someone walking by. We have several large “showstopper” type demonstrations, but these are complemented by giveaways to keep the conversation going at home. These giveaways must be cost-effective in order to create and distribute thousands of items, which drives the creation of the “Pocket Optics” described in the following sections. Each of these easily fit in a wallet, perfect for optics demonstrations on-the-go.

3.1 Pixel Viewers

A simple business card and a macro lens creates a “Pixel Viewer”, which is a quick way to see different pixels on any type of illuminated screen. In addition, the lens can be placed flush against a cell phone camera and can image very small features. Figure 5 shows images captured through the pixel viewer of small printed features on US currency. When ordered in bulk, these 6mm focal length PMMA macro lenses could be purchased for about $0.17 each.

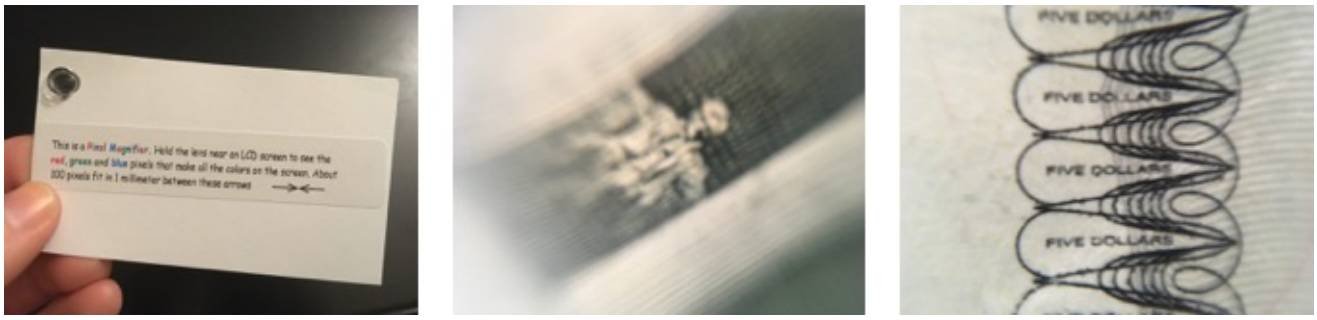

Figure 5. Left: Pixel viewer made from a business card and macro lens. Center and Right: Images of microprint on US currency as captured with a phone camera through the pixel viewer.

3.2 Pepper's Pyramid

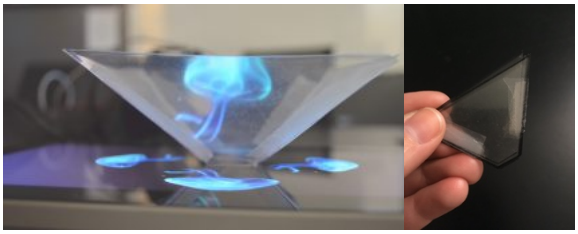

Figure 6. Left: Pepper's Ghost in action, an image appears to float in mid-air. Right: Transparency sheets can be used for a small, phone-sized Pepper's Pyramid and can be folded flat to be easily carried in a wallet.

Pepper's Pyramid (shown in Figure 6) is one of the demonstrations from the D.I.Y. Optics workshop, and can be created from overhead projector transparency sheets. At about $0.46 per sheet, about 10 pyramids can be created from each sheet when the pattern is printed to maximize space, so each pyramid is less than $0.05.

3.3 Fresnel Lenses

The third installation so far in "Pocket Optics" is a miniature Fresnel lens, to go alongside our large Fresnel lens demo which requires two people and safety goggles for everyone in the crowd. While more expensive than the the pixel viewers or Pepper's pyramid giveaways, these require no prep time for construction and provide built-in branding for recruitment to OSC.

Figure 7. As a counterpart to our large Fresnel Lens demonstration, a pocket-sized version provides a souvenir to keep the conversation going at home.

4. ONLINE RESOURCES

The framework for the online hub centralizing the outreach efforts for OSC was created in 2018 as an initiative of a NASA Space Grant fellowship [6]. The website (https://wp.optics.arizona.edu/oscoutreach/) has grown to include a

variety of demonstrations and lesson plans, with an outreach guide, event calendar, and videos of OSC students leading demonstrations. Initially created as a method to facilitate training new outreach volunteers, this also serves as a freely accessible multimedia resource for STEM classrooms.

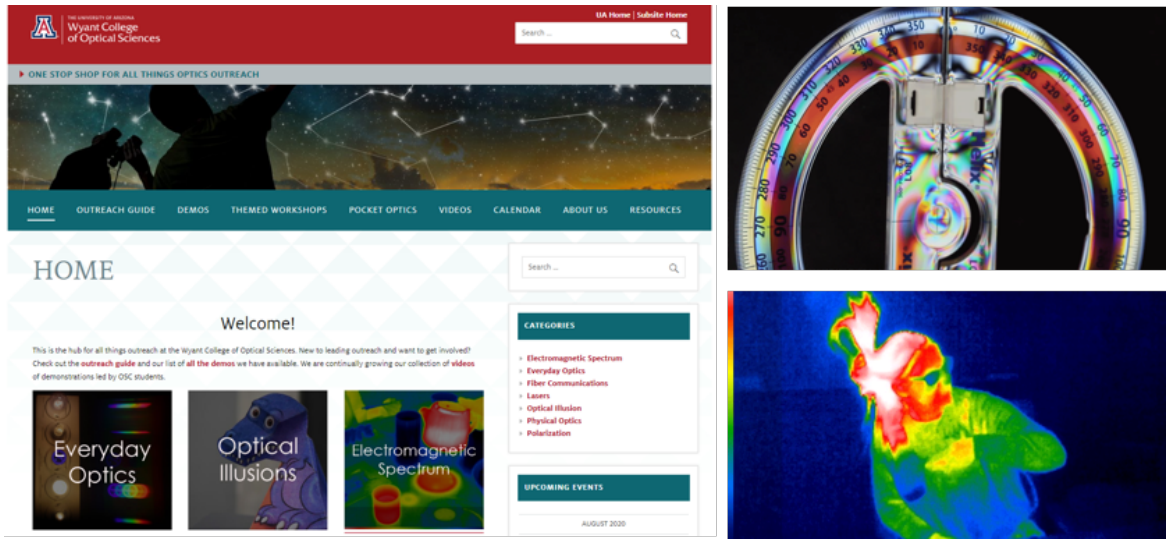

Figure 8. Screenshot of the OSC outreach online hub homepage and images from some of the available demonstrations.

The 2019 LFD had over 500 attendees and the website was utilized to facilitate training volunteers for their assigned demonstration [7]. Figure 9 shows the results of a post-event survey, indicating that the website helped volunteers learn more about their demonstration before participating.

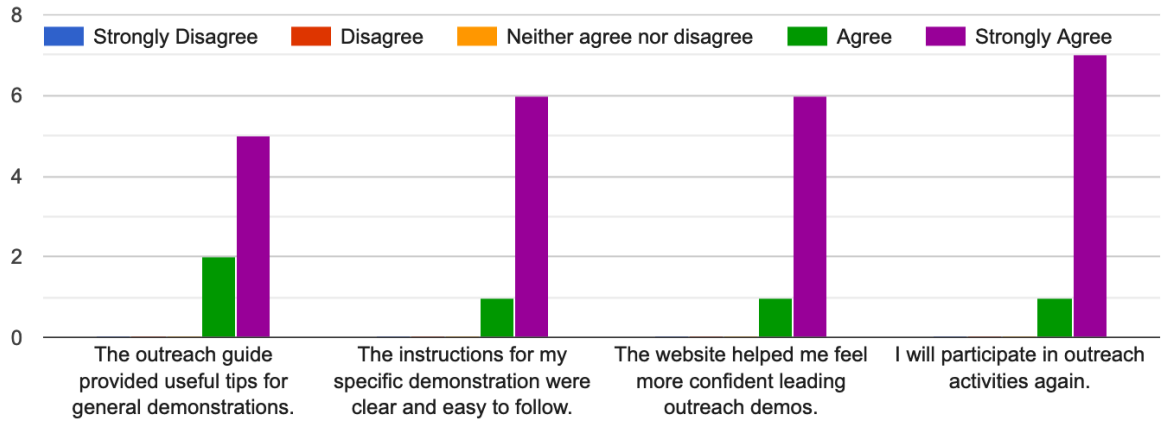

Figure 9. Survey results indicated the website provided helpful guidance for students new to leading optics demonstrations.

With in-person events put on hold in the midst of a global pandemic, these resources will be continually updated in the upcoming year with input from students registered in OPTI 489/589 outreach course. OSC students will be able to connect virtually with students in the Tucson community through maintained relationship with local educators.

5. SUMMARY AND LESSONS LEARNED

The 10th Annual Laser Fun Day was slated for March 21, 2020 and was to include a host of newly developed demonstrations. Unfortunately, the event was cancelled in response to rising COVID-19 cases worldwide. This highlights the growing importance of online resources, and the existing online outreach website will continue to expand in the coming year.

The audience of outreach events varies in size and format, which requires an activity tailored to the particular event. By creating focused workshops centered on a theme, old demonstrations were framed in new ways and refreshed for experienced instructors. These workshops also increased the utilization of demonstrations available within OSC. In contrast to these small workshops, we also created cost-effective giveaways which serve as easy demonstrations to have on-the-go.

6. ACKNOWLEDGEMENTS

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