Optics, Photonics and Quantum Education and Outreach in Southern California - 2024

D. Silberman[1]

1. Quantum Optics Institute of Southern California (QOISC), Rancho Mission Viejo, CA 92694, USA
donn@qoisc.org (Email address of corresponding author)

***Abstract* — This paper reviews some of the optics, photonics and quantum education and outreach programs completed during the 2024 calendar year and includes information on college and career fairs, career exploration days, workshops, in-class hands-on laboratory lessons and experiments. Most of these programs were for students in high school, with some programs for middle school students and a few elementary schools. A brief mention of two ongoing programs, one at a local community college and one at a local university will be followed by a possible future program in development. This information is provided so that the methods may be helpful to people who may be interested in providing similar programs in their geographic regions.**

Keywords — optics, photonics, quantum, education, outreach, students, hands-on demonstrations, college programs.

I. Introduction

Two years ago at this conference, the author presented a paper about teaching quantum to high school students [1]. Since that time, and especially in the 2024 calendar year, much progress has been made and many more educational and outreach programs have been completed. Many of the same education and outreach partners have been main contributors to these programs and will be acknowledged throughout this paper. The main partners are: The Optical Society of Southern California [2] (OSSC), Vital Link [3] (VL), and the Samueli Academy [4] (SA). Other partners, include: The Boys & Girls Club of Central Orange County – College Bound [5] (BGC), Girl Scouts of Orange County [6] (GSOC), NOVA Academy [7] (NA), the City of Irvine [8] (Irvine), UC Irvine Division of Continuing Education [9] (UCI DCE), Pasadena City College Laser Technology Program [10] (PCC), American Center for Optics Manufacturing [11] (AmeriCOM), and Santa Ana College Manufacturing Technology Department [12] (SAC). The main focus of this paper will be on the collaborations with the main partners; and additional discussions describe the programs with the other partners. The goal of this review paper is to offer examples of education and outreach programs that can be implemented with similar partners in other geographic regions globally.

II. The Optical Society of Southern California

The OSSC was established in 1951 and has been in continuous operation ever since. "*It is the aim and purpose of this society to increase and disseminate the knowledge of Optics and closely allied sciences, to promote the mutual interest of investigators, teachers and students in these fields, and of designers, manufacturers and users of optical instruments and allied scientific apparatus as well as those who have optics as a hobby, and to encourage cooperation and establish acquaintanceship among these persons* [13]*"* The OSSC uses it's Education and Outreach Committee to help achieve it's aim and purpose and the author has served as this committee's chair for many years. The OSSC in collaboration with the QOISC have been the nexus for many optics, photonics and quantum education and outreach programs in Southern California and especially Orange County, California.

III. Vital Link

Vital Link has been in continuous operation for over 30 years and recently, during the COVID years, while it could not provide live in-person programs, took the time to regroup and recommit itself to it's mission; " *dedicated to preparing students for their future careers through experiential learning opportunities* [14]*".* The OSSC and QOISC have partnered with VL for over 10 years bringing optics and photonics education and outreach hands-on demonstrations and exhibits to college and career fairs, career exploration days and other related programs directly to students at schools and other venues. During the past 18 months, VL has partnered with a number of organizations that helped their team provide information about 'Registered Apprenticeships' and that information is now available to OSSC Corporate Members via the OSSC website.

The most recent version of the QOISC hands-on exhibit used at VL (and other) college and career fairs and career exploration days is shown in Fig. 1. The exhibit is composed of many elements that are briefly described here. Starting on the far right hand side there is a custom made fiber optic cable patch enclosure (donated by Shaxon Industries [15] of Orange County and assembled by the author) with two red laser diode 'fault detectors', so the students can actually see the red laser light blinking on and off coming out of two of the bare end fibers. There are easy to read explanations of this exhibit on the plastic enclosure that is used to easily transport the display.

Next there is a 'Spectrum Analysis' display built into a rugged 'Milwaukee' toolbox on wheels with two spectral power supplies with Neon and Mercury spectral tubes. There is a large plastic diffraction grating mounted in a frame in front of the spectral tubes to show the diffracted spectrums of each. And there is a "Sprecturm Analysis" poster mounted above the display for further explanation. Directly next to this is a "Color Integrating Sphere" [16] made by OSSC member Mark Helmlinger and the 'Color Mixing' and Light Matters posters [17] describing how the primary colors of light and paint / ink

work to make up all the colors of the rainbow and many aspects of how light works.

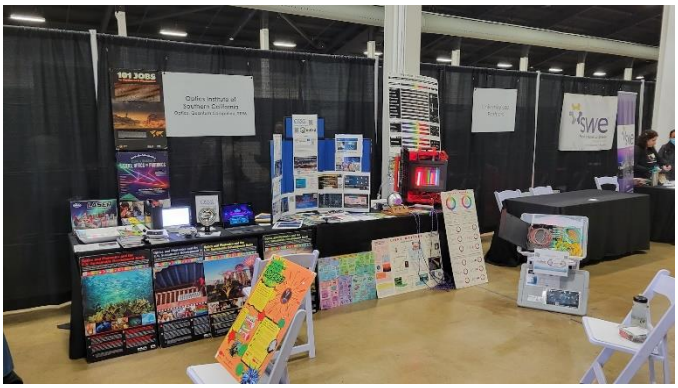

Figure 1. QOISC hands-on exhibit [18].

The large blue display board has many laminated pages stuck on with Velcro dots for easy replacement. This has been used for many years with frequent updates to coincide with the latest versions of the actual displays; most recently with quantum themed information. Most of the posters and the pages on the blue display board are available for download [19] by the students, parents, teachers, administrators and others interested in learning more about any particular topic. There are QR codes on many of the pages for further deep diving into the topics. "The Optics and Photonics and U.N. Sustainable Development Goals" posters are also downloadable [20]. And there is a "Map of Quantum Computing" poster [21] that students are drawn to. There are also many copies of free booklets, "Photonics Infographics" [22] and "Women in Optics" [23] to give away donated from SPIE.

The lefthand side of the demonstration table has a number of additional hands-on exhibits for students to engage. They include: "Quantum Chess" [24] on a live laptop computer, "Miracle Mirror" [25], "Laser Ray Box and Lenses" [26], "Laser Chess" [27], and a live display screen that looks 'white' until the viewer looks through a polarization filter to then observe an SPIE video playing about careers in optics. There are many on-line photo albums showing students interacting with these hands-on demonstrations [28] as well as most of the outreach events over the past 20 plus years.

IV. The Samueli Academy

The Samueli Academy [4] has been in operation for about twelve years and is an Orange County Public Charter School in Santa Ana, California. One main focus at SA is "STEAM" education and their lead engineering instructor is the author's longtime friend, Anthony (Nino) Polizzi [29]. For the past few years (the post-covid years) the author has been volunteering at SA to help teach optics, photonics and quantum to the engineering students. Most recently in the Fall 2024, they have introduced the students to fiber optics by using a number of kits specifically designed for this purpose [30]. The first and most successful hands-on lesson was the measuring the speed of light in a fiber optic [31].

In preparation for this lesson, the students were first introduced to oscilloscopes and how they function and some basic introductions to optics and fiber optics. On the day of the actual experiments, the materials were set out for the students to set up and calibrate the system with a very short 15 cm length of plastic fiber optics. After making the appropriate adjustments to the oscilloscope settings and correctly attaching the electronics and fiber optics, they were able to measure and record the timing of the light pulses through the 20 m length of plastic fiber optics.

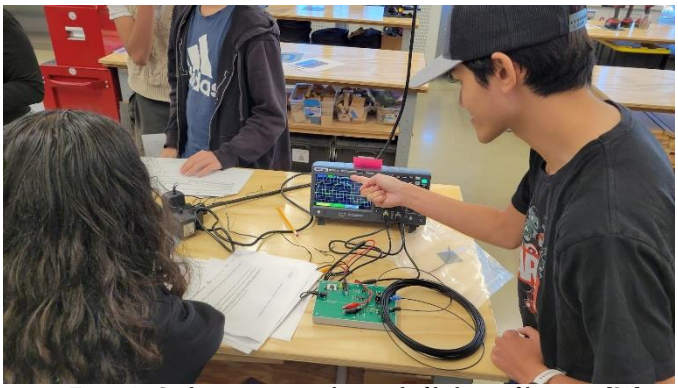

Figure 2. Students measuring the speed of light in a fiber optic [32].

While the kits come with excellent student guides, Polizzi prepared much SA structured pages for the students to use as their guide and short worksheets for them to record their measurements and calculate their results to obtain the speed of light they measured in their experiments. Two other fiber optics experiments were attempted with additional kits with varying degrees of success. At the end of the semester, the students were given a survey asking (in part) what they liked best about the course. Approximately 80% indicated they enjoyed the lessons on light and fiber optics the best.

V. Other Outreach Partners

Three other outreach partners have been very helpful in the past couple or years; The Boys & Girls Club of Central Orange County – College Bound [5] (BGC), the Girl Scouts of Orange County [6] (GSOC), and NOVA Academy [7]. The BGC invited the QOISC to provide a STEM Workshop at their new College Bound facility in Santa Ana, where the author introduced the students to Quantum Computing and helped them use laser pointers and diffraction gratings to learn about physical optics.

Figure 3. Students with their new SPIE Women in Optics notebooks [33].

These students choose to attend this workshop and were given SPIE Women in Optics notebooks to learn about successful women in optics related careers in addition to their hands-on experiences. They got to take home the diffraction gratings they used in the experiments to share with their families and friends.

The QOISC was also invited to participate in the BGC's Annual College and Career Fair in October 2024 and photos [34] showing all the other exhibitors give a sense of how the QOISC exhibit differs from them. This is a theme that exists at many of the college and career fairs the QOISC participates.

The GSOC [6] invited the OSSC & QOISC to participate in their Annual STEM Expo held at the Orange Coast College Planetarium. They provided a unique location at that venue where the existing planets, meteorites and related signage blended nicely with QOISC exhibits as shown in Fig. 4.

Figure 4. QOISC exhibit at the GSOC STEM Expo [35].

Here, OSSC volunteer and board member Steven Dang stands in the center of the exhibit space prior to students flooding in. More photos of the event with many students, parents, teachers and other exhibitors are available at [36]. In this STEM Expo, many of the other exhibitors have wonderful hands-on demonstrations that showcase the OCGS exhibitors' creativity inspiring the attendees.

The NOVA Academy (NA) [7] invited the author to provide a workshop in June 2024, like the one conducted at the BGOC, but with more students and multiple sessions.

Figure 5. NOVA Academy students use laser pointers and diffraction gratings to learn about spectroscopy [37].

Following the success of the June 2024 STEM workshop, the author was invited back to NA's annual Career Day in November 2024 [38] where many groups of students were brought into the classroom for a short presentation on careers in optics, photonics and quantum followed by plenty of time to explore the hands-on exhibits. At first, the students were shy about approaching the hands-on demonstrations, until one of the older students approached and started exploring. Then the other students followed and before long there were many smiles and gasps of amazement.

Figure 6. Older students approach the polarization demonstration.

Figure 7. More students enjoy the polarization demonstration.

VI. Commemerating Albert Michelson

Orange County, and particularly the City of Irvine, is where Dr. Albert Michelson set up his last attempt to discover the infamous 'ether.' He and his colleagues set up their speed of light measurement experiment there around 1930 and 94 years later a 'marker' was erected, and on June 18, 2024, a ceremony was conducted to commemorate that experiment [39]. The street that enters the Orange County airport is named in Dr. Michelson's honor. Many streets in Irvine are named after famous scientists. In October 2004, the author curated an exhibit at the Irvine Civic Center commemorating this experiment [39].

VII. Educational Programs

Two longstanding educational programs in Southern California are the Optical Engineering / Optical Instrument Design program at UC Irvine Division of Continuing Education [9] (UCI DCE), and the Laser Technology Program at Pasadena City College [10] (PCC). Both programs had their origins at Irvine Valley College [40], [41], which to this day continues to use the word "Laser" as its mascot.

The optics, photonics, and quantum education outreach programs described in this paper (and all previous programs involving the author, the OSSC and QOISC) have promoted these programs to students as educational pathways available in Southern California to careers using these technologies. A new related and complimentary program has been proposed by AmeriCOM [11] in collaboration with the OSSC / QOISC to teach precision optics manufacturing at Santa Ana College's Manufacturing Technology department [12]. On January 31, 2024, at the SPIE Photonics West conference, the author was invited to participate in a panel discussion, 'Creating "Ecosystems" to Produce the Next Generation of Optics Technicians' [42] regarding this type of program. Subsequently, in March 2024, a meeting was held at Santa Ana College, [43], that followed many months of discussions about establishing this new program. Discussions are still under way and the author and others hope to begin teaching in the Fall of 2025or soon thereafter.

SUMMARY

This paper has reviewed some of the optics, photonics and quantum education and outreach programs completed during the 2024 calendar year and included information on college and career fairs, career exploration days, workshops, in-class hands-on laboratory lessons and experiments. One goal was to provide information and examples that may be used by others to promote this type of education and outreach in their geograpich regions. Finding and engaging willing and able partners is a key to this type of outreach and education.

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