

Photonics Outreach and Education through Partnerships in Puerto Rico

Jonathan S. Friedman^{*a,b}, Andres Diaz^a, Roger Saltares^a, Sarah Luciano^a, Nerivette Molina^a, Smailyn Martinez^a, Alejandro Hernandez^c, Johan de Jesus^d, Yesenia Rivera^e, Antonio Capeles^f, Felipe Alvear^f, Jesus Lopez^a, Miguel Rivera^a, Rey Suarez^a, and Elsa Trujillo^a

^aPuerto Rico Photonics Institute, School of Environmental Affairs, Universidad Metropolitana, 1399 Ave. Ana G Mendez, San Juan, P.R. 00926-2602;

^bSRI International Arecibo Observatory, HC03 Box 53995, Arecibo, PR 00612;

^cCEG Soft, San Juan, PR 00936-8198;

^dDewey University, Box 19538, San Juan, Puerto Rico 00910-9538;

^eUniversity of Puerto Rico, Arecibo Campus, Arecibo, PR 00612;

^fUniversidad del Turabo, Gurabo, PR 00725

ABSTRACT

As the only photonics center in Puerto Rico, the Puerto Rico Photonics Institute (PRPI) has developed education and outreach projects, partnering with other institutions and private companies to optimize the use of available resources. We present our experience, challenges, rewards, and results for the following projects:

- **Tours:** K-12 students visit our facilities in a science tour including a presentation on the Arecibo Observatory (AO) and the Digital Planet Geodome. We present optics demonstrations and other information. In the first three months we hosted fifteen schools impacting over 1,400 students.
- **Outreach:** We have newly active outreach and recruiting activities for Puerto Rico (PR) schools.
- **Teachers:** With the PR Math-Science Partnership (MSP) Program, we have given a full-day workshop on optics and photonics experiments for 5th-12th grade teachers, and a master class at the annual MSP Congress. We have impacted over 500 teachers through these initiatives.
- **Continuing Education:** We have given continuing education courses in addition to the MSP workshops.
- **General Public:** We partner with museums in PR, the University of Turabo, and the AO Visitor Center to build optics exhibits, many developed by students.
- **Video:** PRPI is promoting the 2015 International Year of Light, creating: 1. A short video with students and faculty from the Universidad Metropolitana (UMET) Schools of Communication and Business Administration; 2. A longer video with the production company *Geoambiente*.
- **Apps:** Our website will include ray tracing and wave propagation applications, developed by UMET Computer Science students.
- **Capstone:** Engineering students at the School of Engineering at Universidad del Turabo are developing laser pattern generators.

Keywords: Outreach, Recruiting, Demonstrations, Social Media, Capstone, Continuing Education

* jsfriedman@suagm.edu; phone: +1-787-878-2612 Ext. 256; Fax: +1-787-878-1861

1. INTRODUCTION

The Puerto Rico Photonics Institute (PRPI) is a new initiative of the School of Environmental Affairs at the Universidad Metropolitana (UMET) in Puerto Rico. As a new program, dissemination is vital to its future. In a land suffering from economic depression and brain drain, communicating the existence of an opportunity offered by a new and unique academic and research program provides PRPI with public good will, interest from local industry, alliances with other universities, and governmental and non-governmental support. The information communicated must tie to people's lives, their interests, and career opportunities. It must include an understanding of how photonics are not just lasers and sophisticated optics for experts, but how these technologies enable many of the developments that are part of people's daily living and their hopes for the future. As we know, these include the Internet, cellular phones, and life-saving medical technologies.

In Puerto Rico specifically, besides the technologies common to developed communities globally, there are various foci of interest to industry and government. Industry has traditionally been dominated by pharmaceuticals, medical devices and, more recently, aerospace manufacturing. These industries depend to an ever greater extent on optical systems for manufacturing, marking and labeling, and process monitoring and inspection. With the educational strength of Puerto Rican universities and the myriad social factors, Puerto Rico is also becoming attractive for industry to carry out research and development. The addition of photonics to the mix enhances that attraction. Government has a deeply vested interest in industry growth for economic and social development, and the Puerto Rico government has been encouraging the growth of aerospace industry, with positive results. Due to this interest, PRPI has been able to garner financial and in-kind support from government and government-supported agencies, particularly the Puerto Rico Industrial Development Company (PRIDCO) and the Puerto Rico Science, Technology and Research Trust (PRST).

Activities to promote PRPI include visits from school groups to the PRPI laboratories, visits to schools from PRPI, presentations for veterans and other groups, teacher training, professional development for engineers and technical professionals, developing museum exhibits, creating online optics applications, and involving engineering programs through Capstone and other opportunities. PRPI is also reaching out to local media through university press releases, radio interviews, and television programs. During the coming months and years we will accumulate data to attempt to measure the effectiveness of the various activities.

2. SUMMARY OF ACTIVITIES

2.1 School Visits

Beginning in September 2014, in a program developed by the Iniciativa Tecnológica del Norte (INTENOR) called Planeta Digital, school groups have been visiting the facilities where the PRPI laboratories are temporarily located. Students receive information and orientations on tropical weather, the Arecibo Observatory, career opportunities, entrepreneurship, and photonics. In the photonics visits, the school groups are divided into small groups that visit PRPI's laboratories. They are shown demonstrations of how light, lasers, fiber optics and related phenomena work, while discussing how these things play roles in their lives and the technologies they hear about. The demonstrations include the following:

1. Fiber optics by showing critical angle and light coupling into a stream of water.
 - a. Students see how the light beam follows a stream of water.
 - b. Internal to the stream, they can see total internal reflection.
 - c. We make the connection between a water stream and a glass fiber.
2. Index of refraction by index matching between glass and baby oil.
 - a. This is a popular demonstration of how physics can make something disappear.
 - b. We use this to help explain what is meant by index of refraction.
3. Transmission of data by light.
 - a. We do free-space transmission and encode sound (music, voice, tones) on the beam. Allowing students to block the light, make adjustments to sound, alignment, and other factors helps to convince them that the light is carrying the sound. For many this is a revelation, as with radio they often do not realize that "radio" is not sound, so the idea that light or radio waves can carry "information" starts to become clear.

- b. We do fiber transmission to demonstrate the power of a fiber. Now the transmission and receiving points do not need to be along a fixed beam path.
- 4. The significance of color and light transmission of energy by popping balloons (see Figure 1) with lasers.
 - a. We ask students what color is. Most have never considered this question.
 - b. We explain how light carries energy, and how they see this in their daily lives.
 - c. We guide them to an answer given by a student in our very first group, in September 2014, that actually an object we see as a certain color is actually “every color but” that color.

We also give a short presentation on PRPI and the opportunities it offers.



Figure 1. Picture of the laser balloon popping apparatus.

In the 8+ months of the program, over 1400 students have visited with their schools and been exposed to lasers and photonics technologies. These students visit the laboratory in groups of 15-20 and including one or two teachers per group. If there are much larger groups, PRPI sets up demonstrations in a conference room capable of seating 50 or more participants.

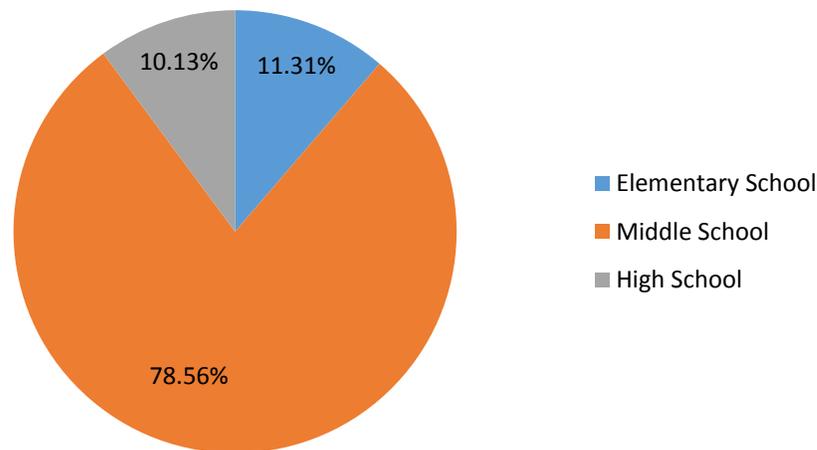


Figure 2. Statistics on school visits to the PRPI laboratories.

In Figure 2, we show the percentages of the over 1400 students by grade level. Over 70% of the students who have seen PRPI demonstrations at our laboratories are in middle school, 7-9th grades (ages 11-15). Of the remaining, nearly 11% are

at elementary school level and 10% are in high school. This is mostly a function of the schools themselves, and not so much that of student interest.

2.2 Presentations for Veterans, Displaced Workers and Other Adults

In 2014 PRPI was awarded a grant from the US Department of Labor TAACCCT (Trade Adjustment Assistance and Community College Career Training) program. The TAACCCT program was created in order to provide a pathway to new careers for workers displaced by plant closings, which were motivated by trade agreements negotiated by the US government. In addition to the so-called TAA-eligible, the TAACCCT program specifies the need to provide career training to veterans and other adults (such as those who are under-employed). PRPI makes presentations and provides materials for outreach to these groups.

Our presentations for this program are aimed to both help existing and promote growth in industries for which photonics provides enabling technologies. Among the priority industries for economic growth within Puerto Rico are aerospace and medical devices.

2.3 Teachers' Workshops

PRPI has carried out three teachers' workshops sponsored by the Puerto Rico Department of Education Math-Science Partnerships program. In these workshops, we utilize kits such as the OSA Optics Suitcase for hands-on activities. We couple these with a subset of the demos we offer to schools, described above. Through this program, PRPI has reached over 500 math and science teachers from public and private primary and secondary schools. In Figure 3 we show the scene at the Conquistador Hotel in Fajardo Puerto Rico during our workshop on 22 November 2014.



Figure 3. A view of the PRPI Teachers Workshop, at the Puerto Rico Math-Science Partnerships Congress, 22 November 2014 in Fajardo, PR.

2.4 General Public

PRPI is currently developing hands-on exhibits to use at public events such as festivals and jobs fairs, as well as placing in museums for special events. The current exhibits are based on a laser pattern generator and permit the user to project art and patterns using one or more laser beams. The development has been carried out by three undergraduate engineering students, two from the University of Turabo and a third from the University of Puerto Rico. There are two designs that are under development. One is a Lissajous figure generator in which a visitor can control the oscillation of a mirror about two axes, and a laser reflected off of the mirror draws a pattern on a screen. The second is a laser projector, coupled with an art program, which allows a user to sketch, write messages, etc. and project the result.

These projects attract people to the technologies of optics and photonics who are not normally drawn to technology by connecting optical technologies with art. We envision this as a way to broaden the impact of photonics and to diversify the population of those interested in photonics careers.

2.5 Website, Social Media, Apps and Videos

From the PRPI website (<http://prpi.suagm.edu>) we connect to a number of online resources, including our Facebook, Twitter, Instagram and YouTube feeds. The YouTube page has a video (in Spanish) explaining photonics and PRPI. A second video is currently in production at the time of this writing, but it should be online by the time of the presentation. PRPI uses social media (and the International Year of Light calendar) to advertise its activities. On the social media, we also post interesting photonics-related news items, generally related to R&D. PRPI also has an App site, hosted at the web domain <http://prphotonics.org>, and which is accessed from our main page. The Apps are interactive programs, the first for wave propagation (**Error! Reference source not found.**) and the second, a ray tracing App, is under development. The wave propagation App is described in a companion paper.

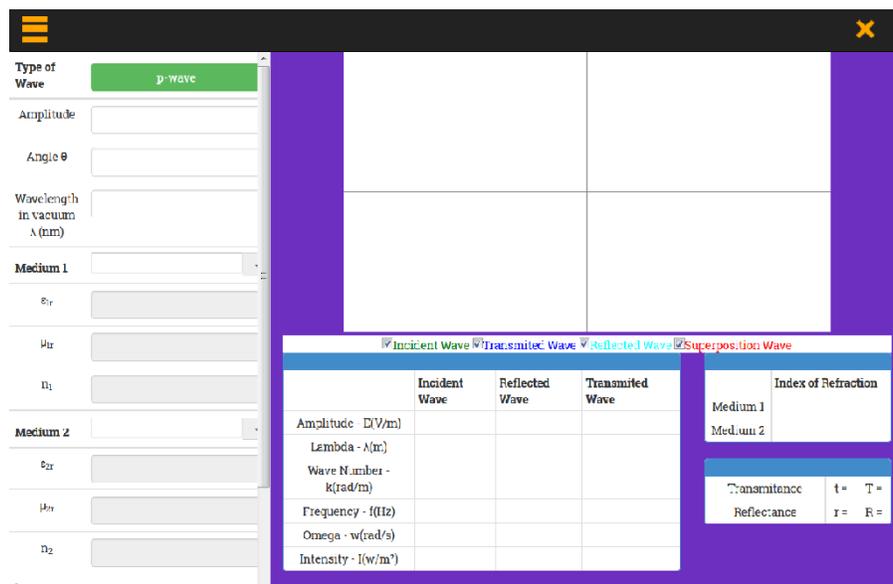


Figure 4. Interface for the PRPI wave propagation online app, which is accessible from our website: <http://prpi.suagm.edu/education>.

As the App development is subject of a separate presentation, we will focus here on production of two videos on photonics and PRPI. These are meant to introduce to the Puerto Rico population what photonics is about and its significance for the local economy. The first video was developed by three students, who are co-authors in this paper, Jesús López, Miguel Rivera, and Ray Suarez. As the background for these students was not in science, the production was a process of them learning about the specific phenomenon to be presented and then determining an appropriate way to make that presentation. The second video is in the final editing stages. It is a professional production by the environment and science production company *Geoambiente*, and subsidized by a grant from the PRST and support from UMET. We expect it to be on our YouTube site (<https://www.youtube.com/channel/UCPd1XqbEsVgw31PGPgHZB8Q>) by the time this work is presented.

2.6 Universities and Researchers

State support for PRPI is founded on the state effort to foment aerospace manufacturing and R&D to Puerto Rico. The Puerto Rico Industrial Development Company (PRIDCO) has established an aerospace cluster in order to bring together government, industry and universities to support this effort. In so doing, they not only attract aerospace industry to the island, but create the infrastructure to support it. The education component of this cluster seeks to join forces and unify resources to permit students at the local universities to obtain a diverse and complete preparation to contribute throughout the wide variety of activities associated with aerospace manufacturing, R&D, and service, among other things.

Through the aerospace consortium PRPI is in the process of gaining a number of important benefits. These include:

- Internships for students at technical and engineering levels.
- A path to offering advanced undergraduate and graduate-level courses without having to have a full program approval. Rather, other universities will validate UMET credits in our courses.
- Research collaborations.
- Career opportunities for our graduates and those who take our courses.
- Participation of professional engineers as PRPI instructors and R&D collaborators.

In addition to aerospace, biotechnology (particularly medical devices) and communications industries are also advancing in Puerto Rico, and their presence can offer similar benefits to PRPI. Much progress has already been made through mutual interests with the medical device industry, and the decades-long history of the pharmaceutical industry is also a promising target for collaboration.

Puerto Rico has many forefront research programs at its universities, and it is of course the home of the Arecibo Observatory. This sector is crucial to the long-term vitality of PRPI, as it is through PRPI post-graduates having research opportunities that the fields of optics and photonics will continue to grow in Puerto Rico.

3. CONCLUSIONS

The Puerto Rico Photonics Institute comes to Puerto Rico at both a precarious and opportunistic moment for the island. While the economy is in dire straits and the population is falling as people move to greener pastures in the mainland US, new prospects are opening up. PRPI is well-placed to be part of a rebirth of opportunity in Puerto Rico. PRPI is positioning itself through outreach, recruiting, media, and collaborations to be a prominent player in this rebirth.

In this paper, we have presented a summary of the activities that PRPI has undertaken to promote its program, the science and technology of photonics, STEAM education, and career opportunities in Puerto Rico.

4. ACKNOWLEDGMENTS

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