TRAVELING LIGHT WITH AN *OPTICS SUITCASE*

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"You can let us out here!" I said to the cab driver, afraid that his stitched-up Volvo would bottom out or simply fall apart as he drove the six of us up a rocky, unpaved hill to a local primary school in Chirapatre, Ghana. Upon arrival, we were greeted by stares from dozens of uniformed students, full of wonderment and excitement, questioning why five *Abrɔfu fuor* (white people) were at their school. Were we rock stars? Movie celebrities? These children had never met white Americans in their life, so they were thrilled to see us follow them into their classroom.

Five Ph.D. candidates - Shawn Divitt, Chris Favaro, Lenore Kubie, Dan Williams, and I - taught science at that underprivileged school during a four-week stay in Ghana, Africa as part of University of Rochester's Integrative Graduate Education and Research Traineeship (IGERT) program on Distributed Renewable Energy. To help us with our lessons, we brought an *Optics Suitcase* packed with hundreds of hands-on science demos that we used to get students excited about science and optics. The *Optics Suitcase* is an educational outreach program created by Stephen Jacobs, a professor at University of Rochester's Institute of Optics, and has reached over 10,000 elementary and middle school students in over 54 countries worldwide since its initial development in 1999[1]. Sessions I had previously taught domestically were received very well, building upon concepts already somewhat familiar to the American students. At Chirapatre Primary School, I expected the young international audience to have a very different perspective, as nearly all science education - grade school through graduate education - is taught in a way that directly relates to daily life and practical applications in Ghana. Therefore, most of the scientific concepts we planned to introduce during the lessons were expected to be completely new to the students.

After living in Kumasi, Ghana and experiencing the day-to-day life in a bustling city and on campus at Kwame Nkrumah University of Science and Technology (KNUST), we strategically structured the workshop in a way that encouraged children to ask questions and pursue practical applications of scientific concepts, such as those seen in the demos. Our goal broadened from merely teaching the key concepts in the Optics Suitcase like diffraction, polarization, reflection, and materials science to inspiring the students to think like scientists by using the scientific method to apply the scientific concepts to daily life, to appreciate solar energy's potential to change their way of living, and to seriously consider college or careers in the sciences. This, we hoped, would have a longer lasting impact than only teaching scientific concepts that the children might not relate to nor remember.

STUDENTS LOOK AT POINT SOURCES THROUGH THEIR DIFFRACTION GRATINGS, OR "RAINBOW PEEPHOLES."

A typical lesson began by investigating a portable heating pad's change from liquid to solid state. We noted observations and characteristics of the liquid pad together with the students, broke the small disk to initiate the crystallization process and release heat, and observed its characteristics again after the change. When it came time to teach a second workshop in the same day, we were faced with the challenge of reheating the pad to bring it back to its liquid state. Usually, it's as simple as placing the pad in boiling water. Since Chirapatre Primary School did not even have the facilities needed to do this, we could only perform this demonstration once per day after resetting the heat pack at our place of residence overnight. Rural Ghanaian villages with no electricity primarily cook over firewood, while metropolitan city homes rely on kerosene as their major source of energy in the kitchen.

STUDENTS AT THE CHIRAPATRE PRIMARY SCHOOL ACTIVELY PARTICIPATE IN THE WORKSHOP.

Each workshop progressed to investigate colors and energy in light. First, we asked the students to look through their *Rainbow Peepholes* at flashlights, and we observed together that white light is made up of many different colors that can be viewed separately using a diffraction grating. Next, when asked to hypothesize what might happen to a green laser pointer when it passed through the diffraction grating, most expected that lots of colors would be created by the tool. They were impressed when only green light emerged, and quickly learned to correctly hypothesize that a red laser would stay red even after passing through the grating.

A SOLAR POWERED FAN DEMONSTRATES THAT ELECTRICITY CAN BE CONVERTED FROM LIGHT.

The most stimulating part of each workshop occurred outside, where all seventy students gathered in a circle in order to investigate the energy in sunlight in a series of demos. First, a lens was used to concentrate sunlight onto a piece of paper, which excited the children as they saw smoke rising from the paper where the light burned a hole. Students laughed as they watched a mini car race around on the dusty ground, stopping whenever it entered a shadow. They gathered around my colleague, Chris, who showed them a spinning fan that was connected directly to a small solar panel, and allowed the children to cover the panel with their hands in order to stop the fan from spinning. The Ghanaian children were all too familiar with using sunlight to dry their food and clothes in the hot climate, and so they were especially interested to see these higher tech uses for their blazing African sun.

TEACHERS OF THE CHIRPATRE PRIMARY SCHOOL WITH THE UNIVERSITY OF ROCHESTER IGERT STUDENTS.

We received great appreciation for the workshop, especially because it contrasted with the usual Ghanaian science lesson, taught on a chalkboard without the use of labs or even classroom props. Typically, local children learn concepts that relate directly to their life, but tend to memorize via call-and-response, instead of experiencing and understanding the material through hands-on experiments and demos. It was especially rewarding to see children's eyes light up when they could see the science in their own hands for the first time.

Teaching hundreds of these grade-school students at Chirapatre was one of the most worthwhile experiences of our stay. We were particularly happy that the students asked hard questions like how to make a real car run on solar energy, how a rainbow is created, and how they can get solar panels for themselves and their families. When quizzed at the end of the lesson, the children correctly respond with the takeaways that we had hoped for: Light has energy and white light is made of many colors. Some students even approached us after class, enthusiastically expressing that they wanted to learn more and that they'd return with us to the US if we could be their teachers. So before leaving Ghana, we trained the teachers and left the Optics Suitcase at the Chirapatre school, in hopes that the workshop will continue to ignite students interest and enthusiasm about science for years to come.

ENTHUSIASTIC STUDENTS GREET THE SCIENCE TEACHERS.

REFERENCES

[1] Canavesi, C., et al. (2012). The Rochester OSA Optics Suitcase: 13 years of middle school outreach. *SPIE Optical Engineering + Applications, Conference on Optics Education and Outreach II*.