University of Southampton Takes Science Into the Schools

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The fact that children as young as eight may already perceive physics as being boring and difficult is one of the causes of the decline in the number of students who go on to study physics in college and graduate school. As part of a plan to revolutionize the way local school children view physics, OSA's University of Southampton (U.K.) Student Chapter has developed an optics roadshow. By taking simple optics experiments and demonstrations to local primary schools, we aim to dispel the negative image of classroom science and help teachers convey the fascination and excitement of physics.

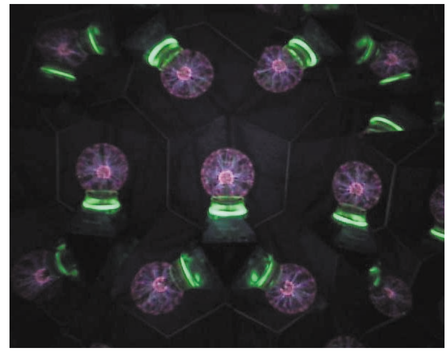
In 1998, our student chapter was asked to set up a few experiments suitable for primary school children ranging in age from five to 11. The experiments, built using equipment from the members' laboratories, were taken to a few local schools. The initial results were so promising that we decided to build a permanent set of optics experiments, which we christened the "Lightwave Road Show." Each year we fine-tune and expand the show. A Web site about the project, developed by student chapter member Stephen Barrington, was named "best site of the week" in the August 9 edition of *New Scientist* (www.lightwave.soton.ac.uk).

Every year during National Science Week, the equipment is installed in our department, the Optoelectronics Research Center (ORC), and local schools are invited to send children to attend demonstrations. The student chapter members then take the show on the road to a number of schools. The members of the chapter perform the experiments, explaining to the students as they go along the physics involved.

The current version of the road show explores five areas of optics: mirrors, lenses, the spectrum, the eye, and telecommunications. Each topic is illustrated by means of simple experiments and demonstrations, accompanied by posters providing easy-to-understand explanations. In each section of the road show, we explain optical phenomena in terms of light rays and photons. Our mascot, Phil Photon, is an indispensable tool for explaining how light is affected by various media.

Parabolic mirrors and a plastic pig

By use of kaleidoscopes, periscopes and mirrors of various shapes, we explain how light is reflected by flat and curved mirrors. A room of mirrors, into which the children can step and observe their multiple reflections, is the centerpiece of this section of the show. Two other popular displays are a set of distorting mirrors and a giant kaleidoscope into which the children can put their heads. The undoubted favorite is a 3D virtual image created with two parabolic mirrors and a plastic pig.



Homogenizer: a lightning ball is placed in a giant kaleidoscope. The children can place their heads inside and observe multiple reflections.

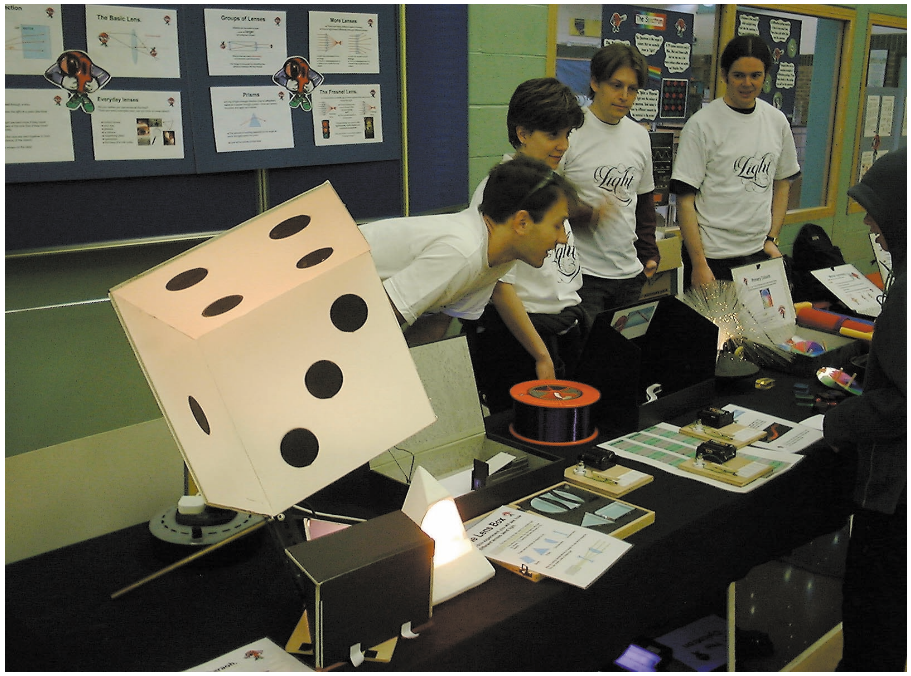
The children try to grab the image and are very puzzled to be left empty-handed. We try to explain to them why the pig appears to be 5 cm above its real location. Another favorite is the match-lighting experiment: the light of a powerful lamp, directed onto a match by a concave mirror, bursts spec-

Wall of mirrors: set of distorting mirrors installed for the younger visitors.

tacularly into flames.

Fun with lenses

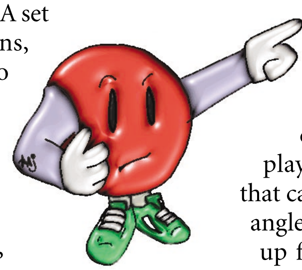
In the lenses section, we explore the principles of refraction by use of a fish tank full of water. We also explain how convex and concave lenses work. We have sets of large lenses that the children can pick up and play with; they range from standard biconvex lenses to the large Fresnel lenses normally associated with the rear windscreen of buses. The way that different-shaped lenses modify the path of light is demonstrated by use of a ray box with multiple parallel rays. The many uses of lenses in everyday life are illustrated with homemade telescopes, old spectacles, camera lenses, and of course, the eye.



ORC students explaining an experiment to a youngster.

The workings of the eye

The eye section encompasses a fully working model of the human eye, which can be used to project and focus the image of an object placed in front of the eye onto a screen representing the retina. A set of 3D photos, optical illusions, and kaleidoscopes are used to keep the children amused. The most popular attraction of this section is the cyclotron: by use of a bicycle pedal and gear mechanism, a stroboscopic light and a laser, the cyclotron shows Phil Photon bouncing up and down. In the rest of the section, with a spinning Benham's disk and posters filled with "magic eye" stereograms and simple optical illusions, we introduce the children to the strange ways in which our brains interpret optical information.



Introduction to the spectrum

The fourth section of our show deals with the electromagnetic spectrum, with emphasis on the visible and ultraviolet parts. We illustrate the components of white light using prisms, multicolored spinning tops, and flashlights with red, blue, and green filters. The children can play with fluorescent objects placed under an ultraviolet lamp. They are also encouraged to write secret messages with security marking pens, which have ink that is visible only under UV illumination.

Communicating with light

The final section of our show is about communicating with light. Here, the children are encouraged to communicate with little homemade Morse-code emitters. They can also play with a set of waveguides that can be used to read text at an angle or upside down. One set-up features light being guided along a bent waveguide or fibers. Another demonstration shows that optical fibers can guide light around obstacles: when a model house is placed between a free-space detector and a transmitter connected to a speaker and a CD player, respectively, the music stops. We show that with an optical fiber link, the optical signal can reach the speaker and the music plays on. Finally, the principles of light guiding in an optical fiber are explained by use of Tyndall's experiment: the light is trapped in a stream of water and the children are encouraged to follow its path along the water with their fingers. In this section, the children can also play with optical-fiber lamps, a fiber preform, and 25 km of purple telecommunications fiber.

Logistics of the show

Depending on the size of the venue and the age of the children attending the show, we install all the experiments in five independent sectors, or we make a smaller stand and take a group of four or five kids through the five subjects. In both cases, we demonstrate big experiments like Tyndall's or the match-lighting experiment, and leave the children free to use the rest of the demonstration as they please and read the posters in their own time.

Over the years that the lightwave road show has been running, we have visited many local primary schools and science fairs. We also regularly set up the road show experiments at the university for visiting children and parents. The response from the children, parents, and teachers is always overwhelmingly positive, and the show is constantly in demand. This response is extremely rewarding, and confirms that we are succeeding in our goal of showing that physics is both fun and highly relevant to everyday life.

Acknowledgments

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The authors are with ORC. Denis Guilhot is a Ph.D. research student who works on silica-on-silicon integrated optics for telecom purposes. Joanne Baggett is a Ph.D. research student who works in the area of holey optical fibers. Ian Musgrave is completing his Ph.D. in the area of power scaling of diode end-pumped solid-state sources.