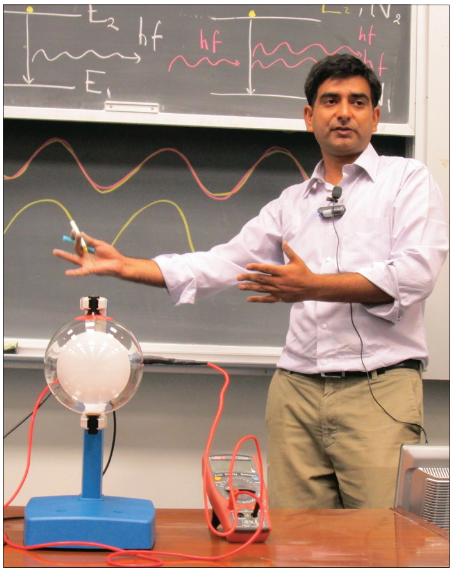
Demonstrating the value of physics

Muhammad Sabieh Anwar says that carefully prepared practical demonstrations can improve students' understanding of physics, especially those in the developing world



Muhammad Sabieh Anwar

Practical power Visually attractive demonstrations can be an effective way to motivate students.

"Tell me and I will forget; show me and I may remember; involve me and I will understand." This ancient Confucian adage, from circa 250 BC, highlights the role that visually appealing practical demonstrations can play in the learning process. It was true back then and it is still true today. Yet with the numerous distractions that students currently face, the need to fascinate and inspire has become more important. The urge to instil this fascination inside the classroom– and within the larger community – is even more critical in developing countries that are undergoing tremendous economic upheaval.

Educational choices in developing parts of the world are often intertwined with economic returns. For example, Pakistan's brightest youth generally turn away from the fundamental sciences, favouring more lucrative options such as business, engineering or medicine. Such alternative career paths usually promise an instant assurance of financial security. Furthermore, parents play an important role in determining their children's career. In many cases, their educational trajectory becomes a family decision that is shaped by social pressures.

In such a culture, students are unduly oriented towards assessments, with the examination becoming an end in itself, and science is reduced to a collection of facts one is expected to reproduce verbatim. Formulae take centre stage while overarching principles are shuddered at. My experience in Pakistan of such straight-jacketed and myopic school curricula is that they leave little room for science education that touches on history, literature and the arts. In doing so, we remove the fundamental fascination of doing science and physics, and jeopardize the very essence of the scientific method by shunning critical inquiry and resisting new unseen scenarios altogether. Hence the lecturers' responsibility is twofold: they must not only teach physics and fascinate, but also encourage students to unlearn old habits.

I teach two large subscription courses at my university: one on electricity and magnetism and the other on modern physics, which includes a module on statistical mechanics. These courses are required for science and engineering majors and are not just restricted to physicists. In the course, I use carefully crafted practical demonstrations to stimulate students. Indeed, I believe such real-life demonstrations are more vital than ever in an age where visualizations and remote virtual experiments inundate the Internet.

Practising physics

My underlying philosophy for demonstrations is simple. The first is to make students remember physics. The second is to emphasize that physics, which emerges from a complex interplay of ideas and tools, is not an encyclopaedia of facts but a process of discovery fuelled by experiments. The third objective is to highlight a connection with the history of science. Practical demonstrations, especially modern versions of historic experiments, show that ideas do not develop in fits and starts but are an evolutionary accumulation.

In my modern physics course, for example, I perform a number of experiments such as J J Thomson's investigation of electron beams through a cathode-ray tube, which in my case I scavenged from an electronic junk store. The idea of quantization is brought home by observing the spectra of various gases under discharge as well as from the fluorescence from cadmium selenide quantum dots. Interferometry and diffraction of light are demonstrated using beamsplitters, razor blades, graphite films and bird feathers, while X-ray fluorescence is used to show how the elements got their atomic numbers. Finally, electron tunnelling is shown by radioactivity and by "frustrated" total internal reflection.

Based on student feedback, I realize that these practical experiments are an important way to enliven the atmosphere. Yet they are not a magic bullet. First, demonstrations done poorly can do more harm than good. You need to practise these experiments and be engrossed in their development offline. There is no bigger disaster than walking into the classroom with a borrowed demonstration kit and ending up in a wild goose chase for the power-up button or hastily rummaging through the product's user manual as your precious lecture time ebbs away. If you want to do a similar experiment for your class, you must practise, practise and practise again.

Second, a practical experiment can easily become a Trojan horse if it does not disseminate to the entire class. What good is a demonstration on tunnelling if those at the back cannot see the beam of light, if the camera operator is obscuring the view of the fringes in an interferometry experiment or when the spectral lines are rendered invisible due to insufficient magnification from the projector?

The timing and duration of these in-class demonstrations are also crucial. They should not be too quick. Equally, they should not drag on so that students get bored. The best experiments have clear outcomes, are visually observable and require hardly any post-processing. Another pitfall I try to avoid is to pretend these demonstrations are a circus act. These are serious activities, the equipment is elegantly and aesthetically designed and all safety precautions must be adhered to.

I believe that practical demonstrations that are built in-house, are visually attractive and directly illustrate novel effects can be a very effective way to motivate students in developing countries to continue to study physics. Done well, they will go a long way towards creating a more viable culture where physics is loved and practised.

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