Active learning training for capacity building in the developing world

Joseph J. Niemela

In the Active Learning in Optics and Photonics program teachers are taught inquiry-based strategies, and low-cost optics technologies are brought to the classroom.

Capacity building—the creation of innovative societies—is easier said than done. This process depends on a number of factors, especially the existence of well-functioning universities (i.e., that create the necessary human capital and are important components in the connection between science, technology, and society). The field of optics and photonics provides an excellent opportunity for many countries in the developing world to advance their focused research and development activities. For such focus on optics and photonics to be successful, however, there needs to be a steady inflow of good students (who have an interest in science) into the universities. Moreover, once these students are enrolled, it is important to steer them toward academic programs in the sciences and to keep their interests pointed in that direction. In other words, what can be done to make sure that these students (especially those that are naturally bright, creative, and motivated, and who could potentially follow any academic subject they want) are not chased away? Furthermore, once these students are committed to the study of optics and photonics, how can they best be prepared for a research-oriented career? It is also important to consider how to train students who take undergraduate physical science courses in their first year, but who plan to pursue a career outside the sciences, as critical thinkers who can contribute to the larger discussion that surrounds technological approaches to societal challenges.

In traditional university education, teachers develop lectures that bring about conceptual understanding (i.e., as a result of expert and clear explanations). Unfortunately, such successful outcomes are rare. Indeed, results from physics education research (a field in which the effectiveness of various teaching methodologies for aiding students’ understanding of basic concepts is measured) consistently show that students rarely change their misconceptions about physical laws, despite being provided with the most logical explanations from their teachers.\(^1\)

Although these pedagogical questions and problems are relevant worldwide, they are most acute in the developing world. Indeed, it was in this context that a team of experts visited the Abdus Salam International Centre for Theoretical Physics (ICTP), Italy, more than 12 years ago. This group included the SPIE chief executive officer Eugene Arthurs, former United Nations Organization for Education, Science, and Culture (UNESCO) physics and math specialist Minella Alarcon, and the late Gallieno Denardo (who was then the ICTP optics coordinator). The outcome of the meeting was a recognition that teachers in developing countries need to be better equipped with skills to make them more effective in preparing students in the

Continued on next page
physical sciences and for helping to retain those who have a natural aptitude for research.

Another outcome of the ICTP meeting was a recommendation for the development of a ‘training-the-trainers’ program. In this program—coordinated within the basic sciences division of UNESCO and called Active Learning in Optics and Photonics (ALOP)²—low-cost optics technologies (thus making it realistically accessible to educators in developing countries) and modern inquiry-based teaching methodologies were combined to produce a curriculum that was aimed at first-year undergraduate students (or those in the last years of high school). The term ‘active learning’ refers to the use of the inquiry-based teaching strategies that are known to keep students engaged and interested in the classroom. These methods also more closely reproduce the way in which scientific work takes place. Active learning techniques (developed on the basis of physics education research results) are defined by the near-absence of lecturing and can be applied to any area of the physical sciences. In particular, however, optics and photonics are naturally appealing to students and can be addressed without the need for expensive equipment (i.e., locally available materials can often be used).

Since 2004, our team at ICTP have teamed up with UNESCO (also working closely with SPIE) to run 27 ALOP workshops for teachers (another is planned for late 2016 in Namibia). In total, we have trained more than 1000 teachers from nearly 60 countries. We use easily fabricated materials and a manual that has, so far, been translated from English into French, Spanish, and Arabic. In our workshops, we cover basic optics and photonics concepts (e.g., geometrical optics and optical communications) in a way that keeps teacher-students actively involved in the learning process. We have also achieved impressive results from follow-up activities (especially in north Africa and Latin America), i.e., where motivated former participants run local workshops to share their knowledge with colleagues. With ALOP, we have also always tried to provide a more interesting context in which to learn basic concepts and to help students understand the link between science and society. Our modules can thus be updated to incorporate current technologies, but always with the constraint that the teaching methodology remains student-centered. In this regard, our connection with SPIE is an important advantage.

In our most recent work—with local ALOP-trained volunteers—we have experimented with bringing our material to actual students. This is a precursor to developing pilot programs in typical classrooms. In particular, we intend to work with public schools in less-developed areas, rather than private schools in larger cities (i.e., which tend to be well-equipped and comparable with those in industrialized countries). Although training trainers is a much more efficient strategy than teaching students, we also need to help our trained teachers introduce active learning activities in their regions’ classrooms. We have thus recently run a few one-day activities, using inquiry-based methods, with public high school girls and female undergraduate students (at Quaid-i-Azam University) in Islamabad, Pakistan (see Figure 1). These workshops have been very encouraging in terms of the students’ abilities to follow the facilitators and to fully engage in the discussions, as well as their inspiring and almost insatiable curiosity.

In summary, we have developed the Active Learning in Optics and Photonics program (in association with UNESCO and SPIE) to provide active learning techniques training to teachers in developing countries. The ultimate aim is to improve capacity building in these countries by providing improved science education. To date, we have conducted almost 30 workshops with teachers and have recently begun working directly with students in classrooms. We are now planning an additional experimental activity in which we will expand our volunteer-based experiment to schools in more remote areas (i.e., the Kyber Pakhtunkhwa region of Pakistan) that have no electricity. This work will provide a better test of how much we can achieve with limited facilities, and when our workshops are fueled mainly by the participants’ desire to learn.

The author is grateful for the support of SPIE in helping to bring both basic and advanced training in optics and photonics to scientists from the developing world (at the ICTP), and in particular for its generous (from its conception) and continuing support to the ALOP program.

Author Information

Joseph J. Niemela
Abdus Salam International Centre for Theoretical Physics (ICTP)
Trieste, Italy

Joseph Niemela coordinates optics activities at the ICTP, where he also serves as coordinator of the Global Secretariat of the International Year of Light and Light-based Technologies 2015. He is a member of SPIE and an elected Fellow of the American Physical Society.

Reference